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JULY 1975

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REGIONS, REGIONAL OFFICES ★, & AREAS

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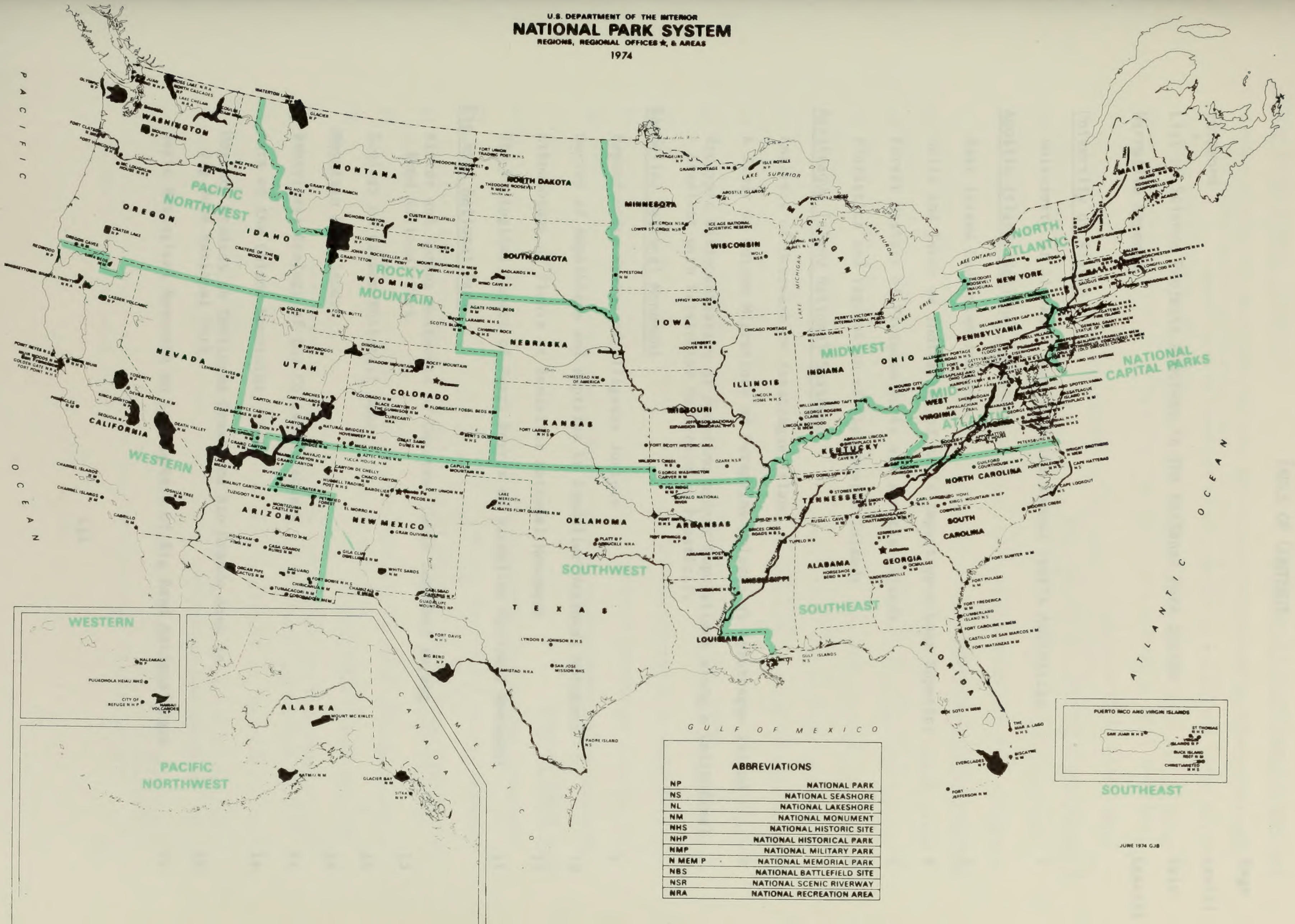

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Foreword

This is the latest report in a series that began in 1968. However, reports for 1970 and 1971 were never compiled and published due to circumstances beyond our control.

The following report is in four parts: (1) a list of science projects underway in the National Park System; (2) narrative progress reports from National Park Service scientists and contractors; (3) an addendum consisting of narrative progress reports submitted after completion of 2 above; and (4) a bibliography of reports and publications that pertain to park areas and that were received during 1973.

Additional copies of this report are available from the Office of the Chief Scientist, National Park Service, Department of the Interior, Washington, D.C. 20240 and the following offices:

Regional Chief Scientist
Mid-Atlantic Regional Office
National Park Service
143 South Third Street
Philadelphia, Pennsylvania 19106

Regional Chief Scientist
National Capital Parks
National Park Service
1100 Ohio Drive, S.W.
Washington, D.C. 20242

Regional Chief Scientist
Southeast Regional Office
National Park Service
3401 Whiiple Street
Atlanta, Georgia 30344

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National Park Service
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Santa Fe, New Mexico 87501

Regional Chief Scientist
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Seattle, Washington 98101

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National Park Service
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San Francisco, California 94102

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North Atlantic Regional Office
National Park Service
150 Causeway Street
Boston, Massachusetts 02114

Regional Chief Scientist
Midwest Regional Office
National Park Service
1709 Jackson Street
Omaha, Nebraska 68102

Chief Scientist
National Park Service Science Center
Room B-202, Building 1100
National Space Technology Laboratories
Bay St. Louis, Mississippi 39520

Chief Scientist
Denver Service Center
National Park Service
P.O. Box 25287
Denver, Colorado 80225

LIST OF SCIENCE PROJECTS
UNDERWAY IN THE NATIONAL PARK SYSTEM
DURING 1974

DATA FROM SUPERINTENDENT'S
ANNUAL RESEARCH REPORTS

EXPLANATION OF COLUMNS

Column 1: Projects are consecutively numbered for reference purposes in this list only.

Column 2: The RSP number. (All Service-sponsored projects should have one.)

Column 3: Title of Project.

Column 4: Names of Investigators.

Column 5: Organizational Affiliation of Investigators.

Codes for Columns A, B, and C

Column A: Funding Source

1. NPS Office of Natural Science Studies
2. Other NPS M&P
3. NPS Construction
4. Other Federal Agency
5. State Agency (not university)
6. University, College, Institution
7. Personal

Column B: Personnel

1. NPS
2. Other Federal Agency
3. State Agency
4. University, College, Institution
5. Individual - no affiliation
6. Other

Column C: Status of Project

0. Proposed, but not started because of lack of funds.
1. Proposed, funds available, but not allotted for some reason.
2. Proposed, funds allotted, but actual work not started.
3. Progressing, will continue for indefinite number of FY's.
4. Progressing, will continue for 3 more FY's beginning next July 1.
5. Progressing, will continue for 2 more FY's beginning next July 1.
6. Progressing, will continue for one more FY beginning next July 1.
7. Progressing, expected to be completed prior to next July 1.
8. Field work complete, final report not summitted.
9. Field work complete, final report in, awaiting approval.
10. Project completed, including approval of final report.

ABBREVIATIONS

Acad	Academy
Agcy	Agency
Agri	Agriculture, Agricultural
Am	America, American
Aud	Audubon
Biol	Biology, Biological
BLM	Bureau of Land Management
Bot	Botanical
BSFW	Bureau of Sport Fisheries & Wildlife
Bur	Bureau
C	College
CA	California
CEQ	Council on Environmental Quality
Comm	Community, Commission
Cons	Conservation
Coop	Cooperative
CPSU	Cooperative Park Studies Unit
CRF	Cave Research Foundation
Ctr, Ctrl	Center, Central
Dept	Department
Des	Desert
DHEW	Department of Health, Education and Welfare
Div	Division
E	East
Ecol	Ecology, Ecological
Eng	Engineer
Env	Environment, Environmental
F & G	Fish and Game
F & W	Fish and Wildlife
Fdn	Foundation
Fed	Federal
For	Forest
Ft	Feet, Foot
Geog	Geographic, Geographical
Geol	Geology, Geological
Hist	History
Inst	Institute
LA	Los Angeles
Lab	Laboratory
Mass	Massachusetts
Me	Maine
Mem	Memorial
Mgt	Management
MIT	Massachusetts Institute of Technology
Monum	Monument
Mt	Mount, Mountain
Mus	Museum

Nat	Natural, National
NHA	National Historic Area
NHP	National Historic Park
NL	National Lakeshore
NM	National Monument, National Memorial
NMFS	National Marine Fisheries Service
NMNH	National Museum of Natural History
No	North, Northern
NOAA	National Oceanographic and Atmospheric Administration
NP	National Park
NPS	National Park Service
NRA	National Recreation Area
NS	National Seashore
NSF	National Science Foundation
NSS	National Speleological Society
NW	Northwest, Northwestern
Observ	Observatory
Off	Office
ONS	Office of Natural Sciences
Penn	Pennsylvania
Poly	Polytechnic
Prot	Protection
PSWFRES	Pacific Southwest Forest and Range Experiment Station
Pub	Public
Res	Research
Sch	School
Sci	Science, Scientific
SCS	Soil Conservation Service
SE	Southeast
Sect	Section
Serv	Service
So	South, Southern
Soc	Society
St	State
SUNY	State University of New York
Surv	Survey
SW	Southwest
Tech	Technology, Technical
Theol	Theology, Theological
U	University
UC	University of California
UCLA	University of California, Los Angeles
UNLV	University of Nevada, Las Vegas
USDA	U. S. Department of Agriculture
USFS	U. S. Forest Service
USFWS	U. S. Fish and Wildlife Service
USGS	U. S. Geological Survey
USU	Utah State University
W	West, Western
Wash	Washington
Wildl	Wildlife
WWSC	Western Washington State College
YCC	Youth Conservation Corps

1	2	3	4	5	A	B	C
	ACADIA NATIONAL PARK, MAINE Visitors (M): 2,734.9. Gross Acreage: 37,005						
1		Biannual Census of Harbor & Gray Seals	D T Richardson	Me Dept Sea & Shore Fisheries	1	5	2
2		New Archeological Survey of Acadia NP	D Sanger		1	4	9
3	N-3	Island Ecology	M Everly		1	1	8
4		Small Mammal Distribution in Acadia NP	R Rackie		7	5	4
	ALIBATES FLINT QUARRIES, TEXAS Visitors (M): 1.3. Gross Acreage: 92						
5		Pipeline Survey & Salvage	J T Huges K E Taylor		6	4	8
	APOSTLE ISLANDS NATIONAL LAKESHORE, WISCONSIN Visitors (M): 25.6. Gross Acreage: 42,011						
6		Floristics & Vegetation of the Apostle Islands	R G Koch D W Davidson	U Wisconsin, Superior	6	4	6
7		Gulls & Terns as Indicators of Man's Impact upon Lake Superior	J T Harris S W Matteson	U Wisconsin, Madison	6	4	8
	ASSATEAGUE ISLAND NATIONAL SEASHORE, MARYLAND - VIRGINIA Visitors (M): 1,714.4. Gross Acreage: 39,630						
8		Autumn Survey of Migrating Peregrine Falcons	F P Ward R Berry		4,7	5	6
9		Quick Inventory Trapping of Small Mammals to Serve as Basis for Proposed Enlarged Study	H D Quarles	U Virginia	7	4	8
10		Gather Salt Marsh Cordgrasses for Inclusion into PhD Dissertation	J Brodhead	U Mass	7	4	6
11		Analysis of Overwash on Assateague Island	S Leatherman J S Fisher	U Virginia	6	4	6
BADL -	BADLANDS NATIONAL MONUMENT, SOUTH DAKOTA Visitors (M): 1,217.3. Gross Acreage: 243,302						
12		Ecology of Prairie Deer in So Dakota	K Severson	USFS So Dakota Game, Fish & Parks	1,4,5	2,3	3
13		Plant Taxonomy	R Puete	Northern St C	6	4	
14		Regional Geology	J Harksen	St Geol Survey of So Dakota	5	4	
15		Sedimentation Studies	N Salisbury	U Iowa	6	4	

1	2	3	4	5	A	B	C
BADL - BADLANDS NATIONAL MONUMENT, SOUTH DAKOTA (continued)							
16		Anthill Samples	R Hohr	U Minnesota	7	4	
17		Lithologic Materials	D Baker	U Illinois	6	4	
BAND - BANDELIER NATIONAL MONUMENT, NEW MEXICO Visitors (M): 149.0. Gross Acreage: 29,661							
18		Reproductive Status of Alligator Juniper in Bandelier NM, New Mexico	J R Gosz	U New Mexico	1	4	10
19		A Soils Survey of the So Two-thirds of Bandelier NM, New Mexico		Earth Consultants, Inc	1	6	10
20		Herpetofaunal Survey of Bandelier NM	W G Degenhardt	U New Mexico	1	4	7
21		Ecological Study of Feral Burro Impact in Bandelier NM, New Mexico	L Potter	U New Mexico	1	4	9
22		Ethnobotany of Plants of Bandelier NM	T Foxx D Hoard		7	5	7
23		Environmental Resources Inventory - Small Mammal Study	L E Eberhardt M Romine F R Miera	Los Alamos Sci Lab	4	2	10
BIBE - BIG BEND NATIONAL PARK, TEXAS Visitors (M): 191.3. Gross Acreage: 709,088							
24	N-8	Reestablishment of Harlequin Quail in Big Bend NP	R H Wauer	Santa Fe, New Mexico	1	1	6
25	N-31	Ants of the Chisos Mountains, Texas	A VanPelt	Greensboro C	6	4	7
26	N-9A	Behavioral Ecology of the Collared Peccary	J A Bissonnette	U Michigan	6	4	8
27	N-34	Mountain Lion Study	R McBride	Welder Wildl Fdn	6	4	7
28	N-3A	Ecology of the Carmen White-tail Deer	P R Krausman	U Idaho	6	4	6
29	N-18	Field Study & Survey of Chiroptera in Big Bend NP	D Easterla	NW Missouri St U	7	4	6
30	N-33	Winter & Spring Movements of Coyotes in Big Bend NP	D Stine J Scudday	Sul Ross U	4,6	2,4	7
31		Chiggers of Big Bend NP	W Wrenn	U No Dakota	6	4	8
32		Study of Moths of Texas	A Blanchard	Houston, Texas	7	4	3
33		Bryophytes of Big Bend NP	W F Mahler	So Methodist U	6	4	3
34		Limnology Study of Aquatic Resources, RGV, Big Bend NP	O Lind	Baylor U	1,6	4	6

1	2	3	4	5	A	B	C

BIBE - BIG BEND NATIONAL PARK, TEXAS (continued)

1	2	3	4	5	A	B	C
35		Mercury Study in Terlingua Creek & Rio Grande Area, Big Bend NP	J Houston	Sul Ross U	1	4	8
36		Land Snails of Trans-Pecos	E P Cheatum	Dallas Mus Nat Hist	6	4	3
37		Petrographic Study of Alkaline Igneous Rocks of Big Bend NP	M Carmen	U Houston	6	4	4
38		Basic Biological Research on Lepidoptera of Big Bend NP	R O Kendall	San Antonio, Texas	7	4	3

BICA - BIGHORN CANYON NATIONAL RECREATION AREA, MONTANA
Visitors (M): 245.2. Gross Acreage: 140,459

1	2	3	4	5	A	B	C
39		Yellowtail Reservoir & Bighorn River Post - Impoundment Surveys (Fisheries)	S E Swedberg	Montana F & G Dept	5	3	6
40		Creel Census & Growth & Movement Study of Trout in the Bighorn River	H Stevenson	Montana St U	7	4	8
41		Waterfowl Distribution & Population Study	J Denton	Montana F & G Dept	5	3	6
42		Investigation of Conflicts among Recreation Users of the Bighorn River	J Denton	Montana F & G Dept	5	3	6
43		Upland & Big Game Inventory of the Pryor Mountains & Beartooth Plateau	J Denton	Montana F & G Dept	5	3	6

BISC - BISCAYNE NATIONAL MONUMENT, FLORIDA
Visitors (M): 409.7. Gross Acreage: 103,701

1	2	3	4	5	A	B	C
44	N-3	Visitor Impact on the Coral Reef Ecosystem	Davis Tilmant	NPS	1	1	3
45	N-6	Water Quality Monitoring	Tilmant	NPS	1	1	3
46	N-7	Comparison of Manmade & Natural Reefs	Pratt Stone	NOAA NMFS	4	2	8
47	N-8	Marine Survey, Old Rhodes Lagoon	R Holm	Northwestern U	6	4	8
48	N-13	Community Structure among Meiofauna of Tropical Carbonate Beaches	R Holm Hummon	Northwestern U Ohio U	6	4	8
49	N-14	Mist Net Studies on Elliott Key	Stoner	Glassboro St C	6	4	8
50	N-15	Vegetation & Fauna Studies on Totton Key	Hilsenbeck	U Miami NPS	6	4	6
51	N-16	Butterfly Survey, Biscayne NM	Covell	U Louisville	6	4	3
52	N-17	Behavior of Marine Reef Fish	Myrberg	U Miami Marine Lab	6	4	4

1	2	3	4	5	A	B	C
BISC - BISCAYNE NATIONAL MONUMENT, FLORIDA (continued)							
53	N-18	Growth & Distribution, Red Algae, Card Sound	Josselyn	U Miami Marine Lab	6	4	5
54	N-19	Ecology Marine Zooplankton	Reeve	U Miami Marine Lab	6	4	5
55	N-20	Sedimentary Processes & Growth History of Carbonate Mud Bank	Warzeski	U Miami Marine Lab	6	4	5
56	N-21	Thermal Tolerance Sea Grasses	Hixon	U Miami Marine Lab	6	4	6
57	N-22	Trophic Studies of Benthic Protozoa	Lee	U Miami Marine Lab	6	4	6
58	N-23	Nitrogen Fixation in Seagrass Communities	Taylor	U Miami Marine Lab	6	4	6
59	N-24	Coral Reef Distribution & Factors of Control	Shinn	Energy Resources Div, USGS	4	2	2
60		Growth Rates of Gorgonian Corals	Bayer K Muzik	Inst Marine Sci, U Miami	6	4	4
61		Radiation Pollution Monitoring	Eakin Dolthat	St of Florida, Radiological & Occupational Health Sect	6	4	3
62		Quarterly Survey of Coastal Vegetation	Carlton	Florida Dept Nat Resources Marine Res Lab	5	3	8
63		Reference Collection of Seashells	Carlson	Mus of Sci, Miami	7	6	10
64		Pollution Monitoring	Hebling Pflum Davis	Florida Dept Pollution Control	5	3	3
65		Recovery of Marine Plants in Areas of Thermal Discharge	S Bach	Inst Marine Sci, U Miami	6	4	7
	BLACK CANYON OF THE GUNNISON NATIONAL MONUMENT, COLORADO Visitors (M): 267.1. Gross Acreage: 13,672						
66	N-118	Archeological Survey		U Colorado	1	4	6
67		Peregrin Falcon	J Enderson	Colorado C	2	1	7
BLRI - BLUE RIDGE PARKWAY, VIRGINIA - NORTH CAROLINA Visitors (M): 13,987.3. Gross Acreage: 90,760							
68		General Ecological & Taxonomic Work	D C Bliss	Randolph-Macon Woman's C	7	4	3
69		Natural Areas Inventory of Southwestern No Carolina	R C Bruce	Highlands Biol Station, Inc	5	3	3
70		Geology of Marion & Little Switzerland Quadrangles, No Carolina	J R Butler	U No Carolina	5	4	6
71		Floral Investigations of So Appalachian Mountains	I W Carpenter M L Hicks	Appalachian St U	6	4	4

1	2	3	4	5	A	B	C
BLRI - BLUE RIDGE PARKWAY, VIRGINIA - NORTH CAROLINA (continued)							
72		Geology of Skyland-Dunsmore Quadrangles, W No Carolina	A E Dabbagh	U No Carolina, Chapel Hill	5	4	6
73		Macrolichen Flora of High Mountain Areas above 5000 Ft in So Appalachians	J P Dey	Duke U	6	4	6
74		Collection of Table Mountain Pine Cones Infested by *Dioryctria taeda*	T H Flavell	USDA	4	2	
75		Floristics of Central Virginia Blue Ridge	R S Freer	Lynchburg C	6	4	4
76		Genetic Variation in Field Crickets of Genus *Gryllus*	R G Harrison	Cornell U		4	6
77		Evolutionary Biology of Salamanders of Genus *Plethodon*	R Highton	U Maryland	7	4	4
78		Ecological Survey of Balds along Blue Ridge Parkway in No Carolina	J H Horton L Gaines	W Carolina U	6	4	5
79		Gypsy Moth Survey - Trapping	W D Jones	USDA	4	2	10
80		Raptor Research: To Collect Data on Occurrence of Raptorial Birds from Asheville District So on Blue Ridge Parkway	S Knickerbocker	USFS	4	5	3
81		Useful Plans of the Blue Ridge from Selected Areas	A Krochmal	Southeastern For Experiment Station	4	2	3
82		Collecting Plant Sepcimens for Botanical Herbarium	D H Krouse	U No Carolina, Chapel Hill	7	5	3
83		Contribution to the Knowledge of High Altitude Beetle Fauna of So Appalachians	L L Lampert, Jr		7	5	3
84		Botanical Survey (General) Alleghany County, No Carolina	J L Mackay, Jr	Appalachian St U	7	4	3
85		Population Structure & Ecological Genetics of Land Snail *Triodopsis albolabris*	G F McCracken	Cornell U	6	4	6
86.		Collect Twigs & Bus (Winter); Leaves (Summer)	F H Miller		7	5	6
87		Observations on Collections of Lower Forms	C Morlang, Jr	Hollins C	7	4	3
88		Life History of Parasitic Scrophulariaceae	L J Musselman	Old Dominion U	7	4	3
89		Instructional Field Research Techniques for Advanced Biology Classes	W Penfound D Stockdale	Warren Wilson C	6	4	3
90		Vascular Flora of the Carolinas	J D Pittillo	W Carolina U	7	4	3

1	2	3	4	5	A	B	C
BLRI - BLUE RIDGE PARKWAY, VIRGINIA - NORTH CAROLINA (continued)							
91		Common Tree Species	C Parks	Highlands Biol Station, Inc	7	4	3
92		Survey of Vascular Flora of Central Virginia Blue Ridge Mountains & Studies on Unusual Vascular Epiphytes	G W Ramsey	Lynchburg C	6	4	3
93		Comparative Vegetation Analyses of Five Spruce Fir Areas in the So Appalachians	S K Schwarzkopf	Furman U	7	4	10
94		Locating & Sampling Natural Rhododendron Hybrids	F W Shield	Newport News, Virginia City Park & Norfolk Bot Gardens	7	5	3
95		Survey of Terrestrial Invertebrates of No Carolina	R M Shelley	No Carolina St Mus	7	3	3
96		Geological Survey of the Blue Ridge	E W Spencer	Wash & Lee U	6	4	3
97		Ferrum College Environmental Center	J D Stogner	Ferrum C	6	4	3
98		Collection of Vascular Plants & Bryophytes	J R Taylor	Mars Hill C	6	4	3
99		Investigations of Genus *Desmognathus* in So Appalachian Mountains	S G Tilley	Smith C	6	4	3
100		Investigation of Winter Stonefly Fauna in Blue Ridge Mountains of No Carolina	V R Tolbert	U Tennessee	7	4	3
101		Biosystematics Study of the Eastern Species of *Heuchera* (Saxifragaceae)	E F Wells	U No Carolina, Chapel Hill	7	4	6
102		Biosystematics of the Bloom Forms of *Rhododendron calendulaceum* (Michx) Torrey	F F Willingham, Jr	Wake Forest U	7	4	10
103		Fusiform Rust Testing Center	R D Wolfe	USFS	4	2	3
104		General Collection for Identification Purposes	J D Yelton	Brevard C	7	4	3
105		Population Dynamics of *Pitymys pinetorum*	J S Ziesenis	No Carolina St U	5	4	6
BRCA - BRYCE CANYON NATIONAL PARK, UTAH Visitors (M): 410.3. Gross Acreage: 36,010							
106		Basic Processes of Erosion	R F Hadley	USGS	4	2	4
107		Rates of Cliff Recession & Denudation of Land	R F Hadley	USGS	4	2	4
108		Changing Conditions & Trends of Forest Communities of Bryce Canyon	H Buchanan	Weber St U	6	4	6

BRCA - BRYCE CANYON NATIONAL PARK, UTAH (continued)

1	2	3	4	5	A	B	C
109		Nesting Birds in a Yellow Pine Forest, Bryce Canyon	R H Gerstenberg	Reedley C, CA	7	1	4
110		The Genesis of the Erosional Forms, Bryce Canyon NP	R C Lindquist	U Florida	6	4	4

BUFF - BUFFALO NATIONAL RIVER, ARKANSAS
Visitors (M): 205.9. Gross Acreage: 94,146

1	2	3	4	5	A	B	C
111		The Vascular Flora of Lost Valley, Newton County, Arkansas	R Thompson	SW Missouri St U, Springfield	7	4,5	7
112		Ascertain Growth Rates of Certain Freshwater Mussels	R Ray	U Arkansas, Fayetteville	7	4,5	7

CACA - CARLSBAD CAVERNS NATIONAL PARK, NEW MEXICO
Visitors (M): 672.4. Gross Acreage: 46,755

1	2	3	4	5	A	B	C
113	N-1a	Microclimate in Cave	J S McLean	USGS	1	1,2	8
114	N-6a	Cave Inventory	C M Peterson	NPS	2	1	4
115	N-11a	Fire as a Management Tool	G M Ahlstrand M R Glass	NPS	2	1	5
116	N-12	Range Survey & Wildlife Browse Analysis	M R Glass R E Reisch G M Ahlstrand	NPS	2	1	10
117	N-13	Population Dynamics of Mexican Freetail Bat	K N Geluso J S Altenbach D E Wilson	U New Mexico NMNH	1	2,4	6
118		Pollution from Birds in Cave (Advisory)	R T O'Brien R J Raitt	New Mexico St U	1	4	10
119		Pollution from Birds in Cave (Microflora)	D E Gardner B J Little	NPS	2	1	3
120	N-9	Rock Stress Studies	J S McLean	USGS	4,7	1,2	10

CAPE HATTERAS NATIONAL SEASHORE, NORTH CAROLINA
Visitors (M): 1,717.3. Gross Acreage: 30,326

1	2	3	4	5	A	B	C
121	N-2a	Ecology of Sand Dunes	W W Woodhouse	No Carolina St U	5	4	4
122	N-16	Outer Banks Coastal Shore Processes & Erosion	R Dolan	W Virginia	4	4	3
123		Abundance, Distribution & Use of Bird Habitats	R Dolan P A Buckley	W Virginia NPS	1	1	6
124		Distribution & Abundance of Biting Insects in Coastal No Carolina	R Axtell		5	4	5
125		Response of Barrier Is. Vegetation to Oceanic Overwash & Its Management Implications in Cape Hatteras NS, No Carolina	P J Godfrey	U Mass	1	4	7

1	2	3	4	5	A	B	C
	CAPE HATTERAS NATIONAL SEASHORE, NORTH CAROLINA (continued)						
126		Beach Nourishment & Shoreline Processes at Cape Hatteras NS, No Carolina	R Dolan	W Virginia	3	1,5	
127		Beach Nourishment & Shoreline Processes at Cape Hatteras NS, No Carolina	J S Fisher	U Virginia	3	1,5	7
128		Study of the Biogeography & Reptiles & Amphibians of the Outer Banks of No Carolina	J D Lazell, Jr J Musick	Mass Aud Soc, Lincoln, Mass Virginia Inst Marine Sci, Gloucester Point, Virginia	6	4	3
	CAPULIN MOUNTAIN NATIONAL MONUMENT, NEW MEXICO Visitors (M): 43.7. Gross Acreage: 775						
129		Biological Studies - Effects of Grazing on Grasslands	A L Gennaro	Eastern New Mexico U	1,2	4	3
CHCA -	CHACO CANYON NATIONAL MONUMENT, NEW MEXICO Visitors (M): 42.4. Gross Acreage: 21,510						
130		Geomorphic Study of Arroyos in Chaco Canyon	R Snead	U New Mexico	1	4	10
131		Study of Upper Cretaceous Strata of Chaco Canyon	C T Siemers	U New Mexico	1	4	10
132		Analysis of Canyon Fill Sediment by Refraction Seismology	C T Siemers	U New Mexico	1	1	6
133		Ecology Survey of the Chaco Canyon Area	L D Potter	U New Mexico	1	4	10
134		Correlation of Indicator Plants & Archeological Sites	L D Potter	U New Mexico	1	4	6
CHIS -	CHANNEL ISLANDS NATIONAL MONUMENT, CALIFORNIA Visitors (M): 43.5. Gross Acreage: 18,388						
135	N-100	Natural Resource Plan Research Basic Data	C Rozaire	LA County Mus	1	4	8
136	N-7	Celestrial Orientation of Talatrid Amphipods	R F Hartwick	UC Scripps Inst	6	4	3
137	N-8	Behavioral Ecology of Nesting *Larus occidentalis*	G L Hunt	UC, Irvine	7	4	7
138	N-9	Evolutionary Relationships of Channel Island Mammals	D K Odell J P Waggoner	UCLA	6	4	7
139	N-10	Rodent Survey on Anacapa & Santa Barbara	R E Main	Oregon St U	6	4	7
140		Survey of Land Birds, Channel Islands	J Diamond L Jones	UCLA	6	4	8
141		Elephant Seal Migration Studies--San Miguel Island	B J LeBoeuf	UC, Santa Cruz	6	4	3

1	2	3	4	5	A	B	C
CHIS - CHANNEL ISLANDS NATIONAL MONUMENT, CALIFORNIA (continued)							
142		Flora of Channel Islands	R Philbrick	Bot Gardens	6	4	3
143		Water Pollution Effects on Marine Biota	D Young M Westbrook	So CA Coastal Water Project	5	3	3
144		Grasshoppers of Channel Islands	D Weisman	Stanford U	6	4	8
145		Brown Pelican Study		CA F & G USFWS USNPS	5	3	3
146		North American Fur Seal Study	R DeLong	US Dept Commerce	2	2	8
CRLA - CRATER LAKE NATIONAL PARK, OREGON Visitors (M): 525.0. Gross Acreage: 160,290							
147	N-2A	Black Bear Study	M McCollum J Blaisdell	NPS	1	1	10
148	N-15A	Elk, Their Ecology & Management	R Manning J Blaisdell	NPS	1	1	3
149	N-13	Vegetation Dynamics, Ponderosa Pine	D Zobel R McNeil	Oregon St U	1	4	8
150	N-6	Water Resources Appraisal	S F Kapustka	USGS	4	2	3
151	N-8	Small Mammal Disease Survey	R A Gresbrink	Oregon St Health Dept	5	3	3
152	N-11	Balsam Woolly Aphid Study	R G Mitchell	USFS	4	2	3
153	N-5A	Ecological Study of Pumice Desert	E L Horn	USFS	4	2	2
154		Biosystematics of *Ranunculus eschscholtzii*	A Hawryski	Malaspina C	6	4	3
155		Glacial & Volcanic Features	J H Hyde	Tacoma Comm C USGS	4,6	2,4	
156		Temporary Profiles in Crater Lake	V Neal	Oregon St U	4,6	4	
157		Taxonomic Status of the Genus *Alnus*	J W Furlow	Michigan St U	6	4	8
CUMBERLAND GAP NATIONAL HISTORICAL PARK, KENTUCKY - TENNESSEE - VIRGINIA Visitors (M): 404.4. Gross Acreage: 20,273							
158	N-2	Natural History Research Project	R Hinkle	U Tennessee	2,6	1,4	7
159	N-3	Survey & Study of Exotic Plants	J K Bailey	Lincoln Mem U	2,6	1,4	3

1	2	3	4	5	A	B	C
DEVA - DEATH VALLEY NATIONAL MONUMENT, CALIFORNIA Visitors (M): 384.1. Gross Acreage: 2,067,792							
160	N-2A	Burro Ecology & Management	C L Douglas	NPS UNLV	1	1.4	3
161	N-5	Mortality of Desert Holly	J C Fisher	NPS UC, Riverside	1	1,4	6
162	N-8	Perpetuation of Native Fishes of Death Valley	J E Deacon	Env Consultants	2	4,5	6
163	N-10	Bighorn Ecology	C L Douglas & park staff	NPS	1,2	1	3
164	N-11	Burro Activity Evaluation					
165	N-13	Hydrological Survey of Death Valley	G A Miller	USGS	1	2	8
166	N-13A	Hydrology of Devil's Hole, Ash Meadows, Nevada	J D Larson	USGS	1	2	3
167	N-14	Ecology of Aquatic Habitats in Death Valley	B Miller	UNLV	6	4	
168	N-15	Social Behavior & Ecology of Ferral Burros	P D Moehlman	U Wisconsin	4,6	4	10
169	N-16	Natural History Inventory Scotty's Castle & Ranch	C L Douglas	NPS UNLV	1	1	5
170	N-17A	Food Utilization of *Cyprinodon nevadensis*	J F Deacon	UNLV	4	4	8
171	N-17B	Marsh Vegetation, Saratoga Springs	W G Bradley	UNLV		4	
172		Salinity Tolerance & Blood Properties of Pupfishes	R Naiman	Arizona St U	4,6	4	9
173		Biosystems of Annual Species of Calyptridium (Portulacaceae)	J M Miller	Oregon St U	6	4	2
174		Energy Balance of Ravens in Dry Heat	H C Heller	Stanford U	4	4	2
175		CNS Regulation of T_b in Antelope Ground Squirrels	H C Heller	Stanford U	4	4	2
176		Ecology of Desert Annuals	F Went	Des Res Inst	4	6	5
177		New Snail Genus & Species	K E Ahern	CA Acad Sci, UC	7	4	6
178		Feeding Habits of Desert Ants	S W Rissing G C Wheeler J Wheeler	U Wash, Seattle Des Res Inst, Reno	4	4	
179		Metamorphism in the Death Valley Region	T C Labotka	CA Inst Tech	6	4	5
180		Endolithic Algae	E I Friedmann	Florida St U		4	
181		Petrography of Owlshead Mountains	J P Calzia	U So CA	4	4	10

1	2	3	4	5	A	B	C
DEVA - DEATH VALLEY NATIONAL MONUMENT, CALIFORNIA (continued)							
182		Geology of Part of Ubehebe Crater Quadrangle	E H Oakes	U Wyoming		4	0
183		Lichen Flora of Death Valley	J E Weier	UC, Davis	7	4	1
184		Silvrian Conodonts	R E Miller F M Hanna	San Fernando Valley St C	6	4	3
185		Physiology of Man in Extreme Heat	D B Dill	Des Res Inst	4	4	3
186		Archeocyathid Faunas of the Lower Cambrian	R A Gangloff	UC, Berkeley	6	4	8
187		Radar Imagery of Death Valley	G L Berlin G S Schaber	USGS Ctr of Astrogeology	4	2	6
188		Precambrian Sedimentary Environments of Death Valley Region	L A Wright	Penn St U	4	4	5
189		Geology of N½ Confidence Hills Quadrangle	L A Wright B W Troxel	Penn St U Geol Soc Am	5	4	5
190		Geology of Chloride Cliff & Big Dune Quadrangles	L A Wright B W Troxel	Penn St U Geol Soc Am	7	4	5
191		Geology of NW¼ Shoshone Quadrangle	L A Wright	Penn St U	7	4	5
192		Geology of Salt Springs & Bearing on Mesozoic Structures in So CA	R G Randall	San Jose St U	6	4	8
193		Microcrustaceans of Cottonball Marsh	R L Watkins	Arizona St U	7	4	6
194		Determination of Tectonic Strain, Death Valley	A G Sylvester F Keller R P Keller	UC, Santa Barbara	6	4	3
195		Measurement of Tectonic Tilting in Death Valley Area	W T Kinoshita G W Greene	USGS	4	2	3
196		Pupfish Development in Cyclic & Stable Environments	J B Schrode	Arizona St U		4	10
197		Photosynthetic Adaption of Plants to High Temperatures	O Bjorkman H Mooney	Carnegie Inst of Wash Stanford U	4,6	4	4
198		Paleoenvironments of Wood Canyon Formation	P E Diehl	Penn St U		4	8
199		Insects of Sand Dunes	D D Giuliani	CA Acad Sci	7	4	3
200		Geology of Marble Canyon Quadrangle	E A Johnson	USGS		2,4	5
201		Joshua Tree Ecology	P L Comanor	U Nevada, Reno	6	4	3
202		Annual Plants	L G Klikoff	U Utah	6	4	

DEVA - DEATH VALLEY NATIONAL MONUMENT, CALIFORNIA (continued)

1	2	3	4	5	A	B	C
203		Survey of Organisms Associated with *Cyprinodon* Fishes	L L Walters	UC, Riverside		4	8
204		Monographic Study of Genus *Boerhaavia*	R W Spellenberg	New Mexico St U		4	4
205		Monographic Study of Genus *Astragalus*	R W Spellenberg	New Mexico St U		4	4
206		Southwestern Flora	R W Spellenberg N Holmgren	New Mexico St U		4	4
207		Geologic Mapping of Telescope Peak Quadrangle	A L Albee	CA Inst Tech	4,6	4	3
208		Deer Mice Genetic Differentiation along Altitudinal Gradients	L R G Snyder	Stanford U	4	4	6
209		Insects of Sand Dunes in W North America	F G Andrews			5	
210		Desert Holly Pathology	E E Banttari	U Minnesota, St Paul	1	4	
211		Sedimentology of Zabriskie Quartzite	J J Barnes	U Illinois		4	
212		Active Faults of Death Valley	G E Brogan	U Nevada, Reno		4	
213		Aquarium Breeding of *Cyprinodon*	A D Castro	Steinhart Aquarium	6	4	10
214		Geological Investigation of Wingate Wash Mine	R S Grabyan	U So CA		4	
215		Geology of Skidoo-Tucki Mt Area, Panamint Range	E W Hildreth	UC, Berkeley		4	
216		Analysis of Alluvial Fan Sediments	B R Maynard				
217		Geology of Central Black Mountains	J K Otton	Penn St U		4	
218		Junco Interbreeding; Solitary Vireo Biosystematics	N K Johnson	UC, Berkeley	6	4	6
219		Speciation Mechanisms in Blister Beetles	J D Pinto	UC, Riverside		4	
220		Moving Rocks on Racetrack Playa	R P Sharp	CA Inst Tech	6	4	6

DINO - DINOSAUR NATIONAL MONUMENT, UTAH - COLORADO
Visitors (M): 332.6. Gross Acreage: 211,050

1	2	3	4	5	A	B	C
221	N-3B	Deer of the Lodore Area	R B Lowry	Utah Coop Wildl Res Unit, USU	1	4	8
222		Investigations of the Movements & Ecological Requirements of the Colorado Squawfish & Humpback Sucker in the Yampa & Upper Green Rivers	K Seethaler C McAda	Utah Coop Fisheries Res Unit, USU	4	4	6

1	2	3	4	5	A	B	C
DINO - DINOSAUR NATIONAL MONUMENT, UTAH - COLORADO (continued)							
223		Ecological Studies of Great Basin Canada Geese in Browns Park	F N Folks	Utah St Div Wildl Resources	4	3	3
224		Collection of Freshwater Snails &/or Land Snails for Museum Research	G Bryce	U Colorado Mus	6	4	
225		Collection of Rock & Plant Specimens for Student Research & Geology Museum	C Almy	Guilford C	6	4	
226		Collection of Rocks & Minerals for Laboratory Study	R W Pierce	U Florida	6	4	
227		Collection of Rocks & Minerals for Geologic Mapping	M M Wood	CA St U, Hayward	6	4	
228		Collection of Astragulus Plants for Biogeochemical Study by NSF	U M Cowgill	U Pittsburgh	6	4	
229		Collection of Living Insects for Mountain, U Colorado Mus	L Urless	U Colorado	6	4	
230		Masters Thesis, Geologic Map of Dinosaur Quarry Area	D Olson V Olson	Fort Hays St C	6	4	
EVER - EVERGLADES NATIONAL PARK, FLORIDA Visitors (M): 1,000.0. Gross Acreage: 1,400,533							
231	N-7	Sea Turtle Rookery Study	G E Davis	NPS	1	1	8
232	N-8	So Florida Birds	W B Robertson, Jr	NPS	1	1	1
233	N-9A	Bald Eagle Studies	W B Robertson, Jr	NPS	1	1	8
234	N-9E	Florida Bay Osprey Study	J C Ogden	NPS Nat Aud Soc	1,2	1,6	8
235	N-12	Wood Stork Studies	J C Ogden	NPS Nat Aud Soc	1,2	1,6	3
236	N-18	Control of Exotic Plants in Everglades NP	L Bancroft	NPS	1	1	3
237	N-26	Florida Bay Crocodile Study	J C Ogden	NPS Nat Aud Soc	1,2	1	10
238	N-28	Cape Sable Sparrow Distribution, Ecology, & Management	H W Werner	NPS	4	1	7
239	N-34	Shark Slough Alligator Study	J C Ogden	NPS Nat Aud Soc	1,2	1	8
240	N-36	Florida Bay Fisheries Research Project	T W Schmidt	NPS	1	1	4
241	N-37	Florida Bay Benthic Mapping Project	T W Schmidt	NPS	1	1	4
242	N-53	Sport Fishery Project	G E Davis	NPS	1	1	6

EVER - EVERGLADES NATIONAL PARK, FLORIDA (continued)

1	2	3	4	5	A	B	C
243	N-54	Commercial Fishery Study	G E Davis	NPS	1	1	6
244	N-59	White Ibis Food Ecology	J A Kushlan	U Miami	6	4	10
245	N-61	Reforestation/Reclamation of Abandoned Farmland	W L Bancroft	NPS	1	1	5
246	N-64	Water Quality Analysis of Florida Bay	T W Schmidt	NPS	1	1	4
247	N-65	Shark Slough (Estuary)	G E Davis	NPS	1	1	3
248	N-66	Shark Slough (Everglades)	J A Kushlan J C Ogden	NPS Nat Aud Soc	1	1	3
249		Round-tailed Muskrat Studies	J Tilmant	NPS	7	1	6
250		Samples for Pesticide Analysis	K Adkins	Ecoimpact Inc, Gainesville			
251		Barnacles & Hermit Crabs	M J Andrejko	U Miami			
252		Insects & Associated Plants	R M Baranowski	U Florida			
253		Photograph Corals	W P Barth	U Michigan			
254		Water, Leaf, & Sediment Samples	T Burton	Florida St U			
255		Sediment Samples	J A Charley	Denison U Gainesville, Ohio			
256		Plant Material	D S Correll	Fairchild Tropical Garden, Miami			
257		Butterflies & Moths	C V Covell, Jr	U Louisville			
258		Sediment Samples	H A Curran	Smith C			
259		Lepidoptera	T S Dickel				
260		Sediment & Water Samples	E Dion	Florida St U			
261		Plant & Sediment Samples	C P Dolson	Penn St U			
262		Sediment & Water Samples	C Dreyer	Florida St U			
263		Ants	R M Duffield	U Georgia			
264		Mosquitos	D G Evans	Florida Div Health Entomological Res Ctr			
265		Peat Cores & Plant Material	C Exarchos	Penn St U			
266		Sediment Samples	D H Farmer	Rensselear Poly Inst			
267		*Brephidium pseudofea* (Lepidoptera)	I L Finkelstein	Georgia St U			
268		Invert Assoc with Bromeliads	D Fish	U Florida USDA			
269		Surface Sediments	R Ginsburg	U Miami			
270		Peat Cores & Plant Material	P Givens	Penn St U			

1	2	3	4	5	A	B	C
EVER - EVERGLADES NATIONAL PARK, FLORIDA (continued)							
271		Aquatic Invertebrates & Plants	T R Hablett	NPS			
272		Water, Leaf, & Sediment Samples	R C Harris	Florida St U			
273		Sediment Cores	D E Hattin	Indiana U			
274		Bees (Halictidae)	A Hefetz	U Georgia			
275		Moths (Glyphipterygidae)	J B Heppner	U Florida			
276		Coleoptera & Neuroptera	P A Holzbauer	Milwaukee Pub Mus			
277		Land Snails	L Hubricht	Field Mus Nat Hist			
278		Odonata	K W Knopf	U Florida			
279		Gnat Bugs (Enicocephalidae)	G Kritsy	U Illinois			
280		Insects & Acarines	L Kudon	U Georgia			
281		Sediment Samples	D E Lanesky	U Miami			
282		Diptera	A G Lavallee	U Georgia			
283		Sediment Samples	W J Meyers	SUNY, Stony Brook			
284		*Oncidium floridanum*	R Nelson				
285		Mosquitos	G F O'Heara	Dept Health & Rehabilitation, Florida			
286		Insects & Plankton	C S Oplinger	Muhlenberg C, Penn			
287		Sawgrass & Associated Plants	F Pearsons	U Miami			
288		Turtle Grass & Sediment Cores	R D Perkins	Duke U			
289		Sediment & Rock Cores	P Quincy	Florida International U			
290		Epiphyllous Fungi	D R Reynolds	Florida Tech U			
291		Sediment Cores	H H R Sharkey	Esso Production Res Co			
292		Sediment Samples	E A Shinn	USGS			
293		Sediment, Rock & Algae Samples	A Siedlecka	Geol Surv of Norway			
294		Lygaeidae (Hemiptera)	J A Slater	U Connecticut			
295		Aquatic Hemiptera	C L Smith	U Georgia			
296		Sediment, Rock, Shell Samples	W Spackman	Penn St U			
297		Salt Marsh Mosquitos	D Sudia	US Pub Health Serv, Denver			
298		Water Samples	D Taylor	Florida St U			

1	2	3	4	5	A	B	C
EVER - EVERGLADES NATIONAL PARK, FLORIDA (continued)							
299		Odonata	K Tennessen	U Florida			
300		Shell Samples	I Thompson	Princeton U			
301		Water, Leaf, Sediment Samples	M Tripp	Florida St U			
302		Sediment Samples	M P Weiss	No Illinois U			
303		Buprestidae (Coleoptera)	S S Wellso	Michigan St U			
304		Small Mammals	H W Werner	Everglades NP			
305		Rock & Sediment Samples	C G Winder	U W Ontario			
	FORT CAROLINE NATIONAL MEMORIAL, FLORIDA Visitors (M): 74.8. Gross Acreage: 128						
306		A Systems Analytic Approach to the Management & Interpretation of Spanish Pond, Fort Caroline NM, Jacksonville, Florida	L D Harris R Kautz	U Florida, Gainesville	2	4	6
307		Archeological Test Trenches on Calypso Island	C H Fairbanks	U Florida, Gainesville	1	4	10
FOJE - FORT JEFFERSON NATIONAL MONUMENT, FLORIDA Visitors (M): 21.8. Gross Acreage: 47,125							
308	N-2	Tern Colony Studies	W B Robertson, Jr G E Wolfenden	NPS U So Florida	1,7	1,4	3
309	N-6	Spiny Lobster Study	G E Davis	NPS	1	1	5
GNMP - GETTYSBURG NATIONAL MILITARY PARK, PENNSYLVANIA Visitors (M): 1,353.8. Gross Acreage: 3,909							
310		A Population Study of White-tail Deer on the GMNP	C Tougas L Kozlowski	Gettysburg C	6,7	4	10
311		Environmental Education Field Study Worksheets & Critique	YCC members A DeRiggs	Camp Eisenhower	4	2	10
312		A Mammalian & Avian Survey Regarding Habitat & Feeding in a Winter Environment	J L Harar	Gettysburg C	6,7	4	10
313		A Survey of the Plum Run Area of GNMP for Use as an Environmental Study Area	E H Weiss	Gettysburg C	6,7	4	10
314		Observations on Chicks of *Coragyps atratus atratus*	R B Nachbar	Gettysburg C	6,7	4	10
315		A Study of Anuran Female Response to Conspecific Male Courtship Calls as Evidenced in *Rana pipiens*	K Papas	Gettysburg C	6,7	4	10

1	2	3	4	5	A	B	C
GNMP - GETTYSBURG NATIONAL MILITARY PARK, PENNSYLVANIA (continued)							
316		A Continuum Study of Round Top, Gettysburg, Penn	R F Timmons P D Matzelle	Mt St Mary's C	6,7	4	10
317		A Survey of an Aquatic Community at Plum Run	P H Price	Gettysburg C	6,7	4	10
318		Toward an Ethic of Environmental Awareness	J A Rodgers	Gettysburg Lutheran Theol Seminary	6,7	4	10
319		The Ecology of Big Round Top	W C Darrah	Gettysburg C		4	10
320		The Interrelation of Substrata, "Organic Content & Type of Life in a Stream"	T Kriger	Gettysburg C	6,7	4	10
321		A Barrier's Effect on Biotic & Abiotic Factors in a Stream	J Cohen	Gettysburg C	6,7	4	10
322		Turtle Pond, an Evaluation of a Turtle Habitat with Special Consideration for the Effects of Temperature	K Niedhardt	Gettysburg C	6,7	4	10
323		Marsh Creek: Damming & Its Effects	S Storm	Gettysburg C	6,7	4	10
324		An Evaluation of a Deer Population	K Niedhardt	Gettysburg C	6,7	4	10
325		Ecology & Behavior of a Population of White-tail Deer in the GNMP	J L Ruos	Gettysburg C	6,7	4	10
GLBA - GLACIER BAY NATIONAL MONUMENT, MONTANA Visitors (M): 51.1. Gross Acreage: 2,805,269							
326	N-12	Sea Otter Studies	Biologist	GLBA	1,2	1	3
327	N-13	Harbor Seal Studies	Biologist	GLBA	1,2	1	3
328	N-14	Intertidal Survey	Biologist field staff	U Arkansas GLBA	1,2,6	1,4	3
329	N-16	Population Biology of Birds	Biologist staff	U Wash NPS	1,2,6	1,4	8
330	N-17	Investigation, Lituya Ice-free Area	Biologist staff	U Wash GLBA U Vermont	1,2,6	1,4	3
331	N-19	Biological Survey	Biologist	GLBA	1,2,6	1,4,5	3
332	N-6a	Variations in Glacier Termini	field staff	Am Geog Soc USGS	2,4,6	1,2,4	3
333	N-6b	Stagnant Glacier Features		Inst Polar Studies	2,6	4	8
334	N-9	Post Glacial Plant Succession		U Minnesota	2,6	4	3
335		Beach Rebound; Glacial Geology	Biologist	GLBA USGS Inst Polar Studies	2,4,6	1,2,4	3

1	2	3	4	5	A	B	C
GLBA - GLACIER BAY NATIONAL MONUMENT, MONTANA (continued)							
336		Humpback Whale Studies	C Jurasz		2,6,7	5	3
337		Glacier Geology Tarr Inlet		Clemson U	6	4	6
GRCA - GRAND CANYON NATIONAL PARK, ARIZONA Visitors (M): 2,028.2. Gross Acreage: 674,286							
338	N-2a	Bighorn Sheep Investigation		NPS-ONS	1	1	3
339	N-10a	Visitor Impact on Campground Biota	P S Bennett	NPS-ONS	1	1	3
340	N-11	Meadow Ecology, North Rim	P S Bennett	NPS-ONS	1	1	0
341	N-12	Determination of Past & Present Composition of GRCA Flora & Fauna	P S Bennett	NPS-ONS	1	1	3
342	N-13	Ecological Evaluation of Dwarf Mistletoe in GRCA	P S Bennett	NPS-ONS	1	1	3
343	N-15	A Limnological Study of the Colorado River	R Johnson	NPS-ONS	1	1,6	6
344	N-16	Ecological Study of Riparian Zone, Inner Canyon	R Johnson S Carothers	NPS-ONS Mus No Arizona	1,6	1,4	6
345	N-17	Feral Burro Management		NPS-ONS	1	1	0
346	N-18	Fire Ecology & Ecological Fire Management	P S Bennett	NPS-ONS	1	1	6
347	N-19	Inner Canyon Deer Movement		NPS-ONS	1	1	0
348	N-20	Host & Site Selection of the Engelmann Spruce Beetle, GRCA	P S Bennett	NPS-ONS	1	1	0
349	N-16	Colorado River Contact Study	J E Hass J Nielsen B Shelby	Human Ecol Res Serv	1	6	6
350		Grand Canyon Archeological Overview	D W Schwartz	Sch Am Res	1	4	6
351		Synthesis of Grand Canyon Archeology	D W Schwartz	Sch Am Res	1	4	5
352		Colorado River Carrying Capacity Study	F Y Bordon H A Weeden D N Thompson		1	4	10
353		Birds of the Grand Canyon Region	R R Johnson S W Carothers	NPS Mus No Arizona	1,6	1,4	5
354	N-1	Kaibab Squirrel Research	J G Hall	San Francisco St C	6,7	4	6
355	N-4	Investigators of Carbonate Aquifiers at GRCA	G L Beck	Private Investigation	7	5	3
356	N-8	Stratigraphy & Paleontology of Chuar Group	W J Breed T Ford	Mus No Arizona U Leicester, England	7	4	6

1	2	3	4	5	A	B	C
GRCA - GRAND CANYON NATIONAL PARK, ARIZONA (continued)							
357	N-9	Formation of Rapids & Erosion of Beaches, GRCA	A Gallenson	U Utah	6,7	4	7
358	N-14	Habitat & Niche Analysis of the Genus *Junco* at GRCA	J R Haldeman	U Arkansas	6,7	4	6
359	N-15	Natural History of Fishes, Mammals, Amphibians, & Reptiles of the Inner Gorge, Grand Canyon	R Suttkus C Jones G Clemmer	Tulane U US Nat Mus Mississippi St U	1	4	6
360		Conodont Biostratigraphy--Temple Butte Formation	D Schumacher	U Arizona	7	4	5
361		Stratigraphy & Evolution of the Coconino Sandstone	B Lundy	U Tulsa	6	4	5
362		Ecological Survey of Small Mammals in the Inner Gorge	S Carothers	Mus No Arizona	6	4	5
363		Blue Springs as a Barrier to *Rhinichthys osculus*	S W Aitchison	Mus No Arizona	6	4	6
364		Survey of Fleshy Fungus Flora of the Southwest	H D Thiers	San Francisco St C	6	4	4
365		Notes on *Papilio indra kaibabensis* Survey of Speyeria of GRCA	R R Wielgus J R Wielgus D Wielgus	Arizona St U	7	4	4
366		Public Health Hazards in Grand Canyon	L Everett	U Arizona	4,5	4	5
367		Social Carrying Capacity in Colorado River Float Trips	S Brickler D A King	U Arizona	6	4	5
368		Grand Canyon Mariners	O D Marston		7	5	7
369		Air Pollution Detection by Laser Beam	R G Layton K O'Dell W Willis	No Arizona U	6,7	4	3
370		Chromosome Variations in North American Fence Lizards	C J Cole	Am Mus Nat Hist	6	4	5
371		Paleontology of the Bass Limestone	M H Nitecki	Am Mus Nat Hist	6	4	7
372		Petrology of the Tapeats Sandstone	E L Burgert	No Arizona U	7	4	10
373		Paleomagnetism in Foliated	S E Cebull D H Shurbert	Texas Tech U	6	4	3
374		Precambrian Paleomagnetic Study of Dikes & Sills	E Larson R Reynolds L LaFountain R Hobblit		6	5	10
375		Petrology of the Redwall Limestone	J W Smith	No Arizona U	7	4	7
376		Late Precambrian Paleomagnetic Correlations	D Elston	USGS Ctr Astrogeology	4	2	3

GRCA - GRAND CANYON NATIONAL PARK, ARIZONA (continued)

1	2	3	4	5	A	B	C
377		K-Ar Dates of Basalts in W Grand Canyon	W K Hamblin M G Best G B Dalrymple C S Gromme	Brigham Young U USGS	4,6	2,4	6
378		Microfossil Identification in the Hakatai Shale by X-Ray	W G Peters	Fiatt, Illinois	7	4	3
379		Geology of Red Butte	J F Haman	GRCA NPS	7	1	6
380		Geology of Travertine Deposits in Grand Canyon	V A Taylor	Prescott C	6	4	5
381		Metamorphic Rocks of Grand Canyon	M D Clark	U Leicester, England	6	4	6
382		Dolomitization	D Zenger	Pomona C, CA	6	4	5
383		Archean Rocks of the Grand Canyon	D M Ragan	Arizona St U	7	4	5
384		Mass Wasting on the Slopes of Grand Canyon	G K Lee	Arizona St U	7	4	5
385		Vegetation Changes along the Colorado River	R M Turner M M Karpiscak	USGS	4,6	2,4	7
386		Investigations on Aquatic Hemiptera	J T Polhemus M S Polhemus	U Colorado Mus	7	4	6
387		Geology of the Cardenas Lavas	I Luchitta J Hendricks	USGS	&	@	&
388		Stratigraphy of Hermit-Supai Formations	E D McKee	USGS	4	2	6
389		Younger Precambrian Basalts in Grand Canyon	I Luchitta J Hendricks	USGS	7	2	7
390		Facies Changes in the Toroweap Formation	C Turner	No Arizona U	6	4	7
391		Conodont Stratigraphy of the Redwall Limestone	D R Walter	Arizona St U	6	4	6
392		Paleoecology of the Kaibab Formation	R H Bruns	U Arizona	6	4	6
393		Sedimentology of the Precambrian Shinumo Quartzite, GRCA	T M Daneker	No Arizona U	6	4	4
394		Affects of Glen Canyon Dam on Fluvial Morphology of Colorado River	E M Laursen S Ince	U Arizona	6	4	7
395		Changes in Fluvial Deposits in the Colorado River	R Dolan A Howard	U Virginia Dept Env Sci	7	4	6
396		Inhibiting Factors in Plant Germination	M Hurst	Brigham Young U	7	4	4
397		Regional Mississippian & Cambrian Stratigraphy	B Purves	U Arizona	6	4	5
398		Geology of Hakatai Formation	S Reed	No Arizona U	6	4	5

1	2	3	4	5	A	B	C
GRCA - GRAND CANYON NATIONAL PARK, ARIZONA (continued)							
399		Origin of the Precambrian 60 Mile Formation	W J Breed T Ford	Mus No Arizona U Leicester, England	5	6	4
400		Arizona Lichen Flora	T N Nash III	Arizona St U	7	4	5
401		Petrographic & Micropaleontological Research	A Chadwick		7	4	5
402		Correlation of Modern Flora & Ancient Packrat Nests	J I Mead	U Arizona	7	4	6
403		Archeology of Unkar Delta	D W Schwartz	Sch Am Res	6	4	6
404		Bright Angel Canyon Archeological Excavation	D W Schwartz	Sch Am Res	6	4	6
405		Walhall Plateau Archeological Survey & Excavation	D W Schwartz	Sch Am Res	6	4	6
GRSM - GREAT SMOKY MOUNTAINS NATIONAL PARK, NORTH CAROLINA - TENNESSEE Visitors (M): 10,447.2. Gross Acreage: 517,014							
406		Studies of Mammal Species	Pelton	U Tennessee	6	4	
407		Black Bear					3
408		European Wild Hog					3
409		Raccoon					3
410	N-6	Acid Pollution in Fishery Streams	Morgan	Tennessee Tech U	1,6	4	3
411	N-7	Forest Cover & Stand Volume Estimates	Buckner McCracken	U Tennessee	6	4	7
412		Effects of Lightening Fires on Vegetation of Great Smoky Mountains	Barden	U Tennessee	6	4	10
413		Chemical Analysis of Flavenoids in *Trillium*	Adams	U Tennessee	6	4	6
414		Carabidae (Beetles) of SE US	Allen	U Arkansas	6	4	3
415		Macrolichens of So Appalachians	Dey	Duke U	7	4	6
416		Survey of Hypomycete Flora of SE US (Fungi)	Dyko	U Tennessee	7	4	5
417		Competitive Interactions among Salamanders	Hairston	U Michigan	6,7	4	4
418		Monographic Studies of N. A. Agaricales (Mushrooms)	Hesler	U Tennessee	6	4	3
419		Evolutionary Studies of Plethodontid Salamanders	Highton	U Maryland	4,6	4	5
420		Amphibians & Reptiles of Great Smoky Mountains NP	Huheey	U Maryland	4,6	4	3

GRSM - GREAT SMOKY MOUNTAINS NATIONAL PARK, NORTH CAROLINA - TENNESSEE (continued)

1	2	3	4	5	A	B	C
421		Biosystematic Study of *Viburnum* of E North America	Jones	No Carolina St U	6	4	4
422		Evolutionary Study of *Claytonia*	Lewis	Wash U	4,6	4	6
423		Beetle Pollination of *Calycanthus*	McCormack	U Connecticut	4,6	4	6
424		Population Structure & Genetics *Triodopsis albolabris* (land snail)	McCracken	Cornell U	4,6	4	6
425		Trees & Shrubs of W No Carolina & E Tennessee	Miller	Waynesville, No Carolina	7	5	6
426		Biosystematic Study of *Cystopteris* (fern)	Pearman	U Tennessee	6	4	6
427		Vascular Flora of the Carolinas	Pittillo	W Carolina U	6	4	10
428		Monograph of *Hydnum* (Fungi)	Restivo	U Tennessee	6	4	6
429		Micropaleontologic Studies of Chert, Cades Cove	Schopf	UCLA	4,6	4	5
430		Bryophytes of the Great Smoky Mountains	Sharp	U Tennessee	6	4	3
431		Bryophytes of the Great Smoky Mountains	Spessard	U Tennessee	6	4	6
432		Variation of *Abies* in the So Appalachians	Thor	U Tennessee	4,6	4	3
433		Investigations of *Desmognathus* in So Appalachians	Tilley	Smith C	6	4	3

GUMO - GUADALUPE MOUNTAINS NATIONAL PARK, TEXAS
Visitors (M): 39.4. Gross Acreage: 76,398

1	2	3	4	5	A	B	C
434	N-9	Ecology of Fire	G M Ahlstrand M R Glass	NPS	2	1	5
435	N-13	Vegetative Survey & Analysis	D K Northington T L Burgess	Texas Tech U	1	4	6
436	N-13	Small Mammal Survey & Analysis	R J Baker H H Genoways R L Packard	Texas Tech U	1	4	6
437	N-13	Data Analysis & Remote Sensing	B S Duran	Texas Tech U	1	4	4
438	N-13	Geologic Mapping & Site Evaluation	C C Reeves	Texas Tech U	1	4	7
439		Meteorological Study	E M Wilkins G M Ahlstrand	ATC Inc NPS	1,2	1,6	7

1	2	3	4	5	A	B	C

GUMO - GUADALUPE MOUNTAINS NATIONAL PARK, TEXAS (continued)

1	2	3	4	5	A	B	C
440		Range Survey & Wildlife Browse Analysis	M R Glass R E Reisch G M Ahlstrand	NPS	2	1	10
441		Location & Inventory of Caves	C M Peterson	NPS	2	1	4
442	N-12	Breeding Avifauna of Woodland Communities	G A Newman	Hardin-Simmons U Texas A & M U	6,7	4	8
443		Pleistocene Biotic Communities	T R VanDevender P S Martin A M Phillips III W G Spaulding	U Arizona	4,7	4	7
444		Quaternary Vertebrate Fauna	L E Logan C C Black	Texas Tech U	6	4	7
445		Recent Mollusca of Guadalupe Mountains NP	R W Fullington	Dallas Mus Nat Hist	6	4	4
446		Bionomics of *Pogonomyrmex maracopa*	J V Moody D E Foster	Texas Tech U	6	4	10
447		Watershed & Land System Classification	E B Fish	Texas Tech U	6	4	10

GULF ISLANDS NATIONAL SEASHORE, MISSISSIPPI
Visitors (M): 1,037.1. Gross Acreage: 142,009

1	2	3	4	5	A	B	C
448		Marine Specimens, Native Plants, Rocks, Minerals	G Corcoran	Gulf Coast Res Lab	5	3	3
449		Marine Specimens	M D Corbett	U Mississippi	6	4	8
450		Vascular Flora	J Stout	U Alabama	6	4	7
451		Marine Specimens	S D Upham	Dauphin Island Sea Lab	5	3	7
452		Marine Specimens	D McCaughan	Biloxi High Sch	6	4	3
453		Vascular Flora	A S Bradburn	Tulane U	6	4	3
454		Bottom Sand	L I Ladner, Jr	U New Orleans	6	4	7
455		Marine Invertebrates	H A Dundee	Tulane U	6	4	7

HALE - HALEAKALA NATIONAL PARK, HAWAII
Visitors (M): 441.3. Gross Acreage: 27,823

1	2	3	4	5	A	B	C
456	N-6	Preservation of the Dark-rumped Petrel	park staff	HALE	2	1	3
457	N-9	Plant Checklist & Herbarium	park staff	HALE	1	1	3
458	N-10	Hawaiian Goose "Nene Park" Plan	park staff	HALE	6	1	3
459	N-11	Pig Exclosure-Kalapawili Ridge	J Jacobi	U Hawaii	1	4	3

1	2	3	4	5	A	B	C
HALE - HALEAKALA NATIONAL PARK, HAWAII (continued)							
460	N-1	The Geology of Haleakala Crater	G Macdonald	U Hawaii	6	4	3
461		Silversword Mercury Content Analysis	N Puerner	U Hawaii	6	4	8
462		Collections of Natural History Materials for Research	J Kjargaard	U Hawaii	6	4	7
HAVO - HAWAII VOLCANOES NATIONAL PARK, HAWAII Visitors (M): 1,613.1. Gross Acreage: 229,177							
463	N-4b	Ecology of Non-native Mammals	J K Baker	NPS	1	1	3
464	N-22	Reestablishment of Nene	J K Baker P C Banko D W Reeser	NPS	1	1	3
465		Biology of *Hibiscadelphus*	J K Baker	NPS	1	1	3
466	N-23	Insect Food & Status of Hawaiian Birds	P C Banko	NPS	1	1	9
467	N-18	International Biological Program	D Mueller-Dombois	U Hawaii	4,6	4	7
468	N-19	Spectroscopic Studies of Volcanic Flames	P Cruickshank	U Hawaii	6	4	3
469	N-20	Volcanic Aerosols & Gasses	R F Pueschel	Mauna Loa Observ	6	4	
470	N-21	Hawaiian Volcanic Gasses	J Naughton	U Hawaii	4,6	4	3
471		Speciation & Migration in Drosophila	R H Richardson	U Texas	6	4	3
472		Behavior, Processes & Causes of Hawaiian Vulcanism		USGS Volcano Observ	4	2	3
473		Magnetic Surveys over the Hawaiian Ridge	R G Zachariadis	U Hawaii	4,6	4	3
HOBE - HORSESHOE BEND NATIONAL MEMORIAL PARK, ALABAMA Visitors (M): 479.6. Gross Acreage: 2,040							
474	N-1	Plant & Animal Resources Basic Inventory	J D Freeman, et al	Auburn U	2,6	4	9
HOSP - HOT SPRINGS NATIONAL PARK, ARKANSAS Visitors (M): 2,314.5. Gross Acreage: 5,779							
475		Origin & Physical Chemical Properties of HS Thermal Water	Sniegocki Bedinger Poole	USGS	1,4	1,2	10
476		Ecological & Limnological Analysis of Gulpha Creek		Southern U	1	4	3

1	2	3	4	5	A	B	C
	INDIANA DUNES NATIONAL LAKESHORE, INDIANA Visitors (M): 63.0. Gross Acreage: 8,329						
477	N-1	Insects	V Reaves	Field Mus Nat Hist		5	3
478	N-2	Christmas Bird Counts	R Tweit M D Schaeffer	Chicago Aud Soc		6	3
479	N-3	Breeding Bird Census	R Tweit E Pitcher	Chicago Aud Soc	7	6	3
480	N-4	Baseline Water Quality Assessment	L Arihood	USGS	4	2	7
481	N-5	Basic Ecosystem Survey	Reshkin Feldman Kiefer Krekeler	Indiana U	6	4	6
482	N-6	Monitoring Program	Corps Eng	Chicago District	4	2	3
483	N-7	Water Quality Monitoring	L Arihood	USGS	4	2	3
484	N-8	Dewatering NIPSCO's Bailly Site	J Marie	USGS	4	2	6
ISRO -	ISLE ROYALE NATIONAL PARK, MICHIGAN Visitors (M): 13.9. Gross Acreage: 539,279						
485	N-1	Ecological Wildlife Study	D Allen	Purdue U	1,6,7	4	3
486	N-2	Investigation of Plant Succession Following Fire	park staff		2	1	3
487		Analysis of the Isle Royale Ecosystem	P Jordan	U Minnesota	1,4,6	4	4
488		Demographic Parameters of Isle Royale Small Mammals	W Johnson	U Wisconsin	6	4	6
489		An Ecological Study of Leaches of Isle Royale	M Grosnick	No Michigan U	7	5	7
490		Beach Texture of Isle Royale	J Sullivan J Pezzetta	U Wisconsin		4	3
491		Interactions of Moose, White Spruce & Balsam Fir	J Edwards	U Michigan	6	4	5
492		Ecological Study of the Amphibians & Reptiles of ISRO	D Moll	Illinois St U	6	4	4
493		Ecology of Spruce Fir Fire History of ISRO	R Janke	Michigan Tech U	1,6	4	3
494		Isle Royale Visitor Study	R Stinson	Michigan Tech U	7	4	5
JECA -	JEWEL CAVE NATIONAL MONUMENT, SOUTH DAKOTA Visitors (M): 81.7. Gross Acreage: 1,274						
495		"C" Cave Exploration	H Conn J Conn		7	5	3

1	2	3	4	5	A	B	C
JOTR - JOSHUA TREE NATIONAL MONUMENT, CALIFORNIA Visitors (M): 503.9. Gross Acreage: 559,954							
496		Ecology of the Bighorn	C Douglas	U Las Vegas	1	4	3
497		Fan Palm Oases	K Frazier	U Las Vegas	1	4	
498		Plant Distribution	P Leary	U Las Vegas	1	4	
499		Ecology of the Joshua Tree	J Hogan	U Las Vegas	1	4	6
500		Desert Use Impact	R Davis	UC, Irvine	4	4	8
501		Water Repellant Soils	J F Osborn	UC, Riverside	4	4	
502		Salvia Nohavensis	C Sterling	Westmont C, Santa Barbara	4	4	
KATM - KATMAI NATIONAL MONUMENT, ALASKA Visitors (M): 12.5. Gross Acreage: 2,792,137							
503	N-10	Icthyology, Limnology	M Dahlberg	NMFS	4	2	3
504	N-18	Vegetation Map of Katmai NM	J G Dennis	NPS	1	1	3
505		Bear Denning Survey	W Troyer J Faro	NPS Alaska Dept F & G	1	1,3	6
506		Moose Population Survey	J Faro W Troyer	Alaska Dept F & G NPS	5	3	3
507		Eagle Population Survey	W Troyer	NPS	1	1,3	6
508		Razor Clam Studies		Alaska Dept F & G	5	3	3
509		Glacier Research	R Motyka	U Alaska	6	4	8
510	N-20	Human Impact on Natural Vegetation	J G Dennis	NPS	1	1	3
KENNESAW MOUNTAIN NATIONAL BATTLEFIELD PARK, GEORGIA Visitors (M): 6,366.9. Gross Acreage: 2,884							
511		Non-cultivated Vascular Plants: Ferns, Gymnosperms, Angiosperms	P E Bostick	Kennesaw Jr C	6	4	1
LAME - LAKE MEAD NATIONAL RECREATION AREA, ARIZONA - NEVADA Visitors (M): 5,939.5. Gross Acreage: 1,813,354							
512		Hydrogeologic Studies of Lake Mead NRA		USGS	1	2	3
513		Geologic Mapping of the W Grand Canyon	P Huntoon G Billingsley	Grand Canyon NHA SW Parks & Monum	6	4	4
514		Rampart Cave Studies	P Martin	UNLV	6	4	3
515		Water Quality Studies of Las Vegas Bay	J Deacon	UNLV	5	4	4
516		Air Pollution Monitoring	R Steele	Des Res Inst UNLV		4	3
517		River Mountains Bighorn Study		Nevada Dept F & G Lake Mead NRA	2,5	1,3	5

1	2	3	4	5	A	B	C
LAME - LAKE MEAD NATIONAL RECREATION AREA, ARIZONA - NEVADA							
518		Largemouth Bass Ecology		Bur Reclamation Nevada Dept F & G	4,5	2,3	3
519		Resource Basic Inventory	C L Douglas	UNLV	1	1,4	4
LAMR - LAKE MEREDITH RECREATION AREA, TEXAS Visitors (M): 1,732.7. Gross Acreage: 45,964							
520		Assessment of Archeological Resources	C B Bousman S A Skinner	So Methodist U	1	4	10
521	N-1	Research on Walleye Perch	J E Kraai J Prentice	Texas Parks & Wildl Dept	5	3	10
522	N-2	Water Quality & Limnology	W A Cooper	W Texas St U	6	4	3
523		Study of Environment of Deposition of Alibates Flint	R Bowers	U Texas, Arlington	7	4	7
LAVO - LASSEN VOLCANIC NATIONAL PARK, CALIFORNIA Visitors (M): 408.7. Gross Acreage: 106,372							
524	N-4	Fungi of Lassen	W B Cooke	U Cincinnati Miami U	7	4,5	3
525	N-22	Glacial Geomorphology of Lassen Volcanic NP	P Kane	CA St U	6,7	4	8
LABE - LAVA BEDS NATIONAL MONUMENT, CALIFORNIA Visitors (M): 140.6. Gross Acreage: 46,500							
526	N-1&2	Geology of Lava Beds	A Waters	USGS	1	1,2	6
527	N-9A	Ecological Wildlife Range Study--Deer	Res Biologist park staff	NPS	2	1	3
528	N-11	Natural History Handbook	park staff		2	1	10
529	N-12A	Bighorn Reestablishment Studies	Res Biologist park staff	NPS	2	1	3
530	N-14	Habitat Restoration Petroglyphs Section	Res Biologist park staff	NPS	2	1	3
531	N-16, 17,18	Fire Ecology	R Martin	U Wash	1	4	5
532	N-20	Vector Control Studies	E E Lusk	CA Dept Pub Health	5	3	3
533	N-21	Road Shoulder Vegetation Management	Res Biologist park staff	NPS	2	1	8
534	N-22	Resources of Petroglyph Section & Peninsula	Murrill Hall Hajas		1	4	10
535	N-24	Exotic Plant Identification Control	Res Biologist park staff	NPS	2	1	3
536	N-25	Wildfire Revegetation	Res Biologist park staff	NPS	2	1	3

1	2	3	4	5	A	B	C
LABE - LAVA BEDS NATIONAL MONUMENT, CALIFORNIA (continued)							
537		Seismicitic Monitoring		MIT	6	6	3
	LEHMAN CAVES NATIONAL MONUMENT Visitors (M): 32.7. Gross Acreage: 640						
538		Preliminary Study of Algal & Moss Growth Control Measures Suitable to Conditions in Lehman Caves	R I Lynn	Utah St U	1	4	3
MACA - MAMMOTH CAVE NATIONAL PARK, KENTUCKY Visitors (M): 1,740.0. Gross Acreage: 52,128							
539	N-1	Hydrology of Mammoth Cave	R V Cushman	USGS, Louisville	1	2	3
540	N-21	Reproductive Regulation of White-tailed Deer	G H Matscke R D Roughton	BSFW	1,4	1,2	4
541	N-23	Ecological Study of Plant Communities	A Faller M T Jackson	Cleveland St U Indiana St U	1,6	4	8
542	N-40	Ecological Effects of Water Pollutants on Fauna of MACA	T C Barr, Jr	U Kentucky	1	4	7
543	N-2	Deer Population Study	S P Troublefield	Kentucky Dept F & W Resources	5	3	3
544	N-8	Hydrology & Geomorphology of Cedar Sink, MACA	R J Hosley	Nat Sci Resource Studies Group	7	5	7
545	N-9	Cartography of Caves	J P Wilcos W P Crowther P Crowther	CRF	6,7	4,5	3
546	N-11	Paleohydrology of Mammoth Cave Flint Ridge Cave System	W B White G Deike	Penn St U CRF Davis-Elkins C CRF	6,7	4,5	3
547	N-12	Hydrology of the Central Kentucky Karst	W B White J W Hess	Penn St U CRF	6,7	4,5	7
548	N-14	Control of Species Diversity in Terrestrial Cave Communities	T L Poulson T C Kane	U Illinois & CRF Notre Dame U & CRF	6,7	4,5	3
549	N-15	Comparison of Cave Stream Communities	T L Poulson	U Illinois & CRF	6,7	4,5	3
550	N-24	Archeology of the Mammoth Cave Area	P J Watson	Wash U & CRF	6,7	4,5	3
551	N-26	Water Quality in Springs & Rivers of the Central Kentucky Karst	D R Rowe M Holmes	W Kentucky U	4	4	8
552	N-27	Sulphate Mineralogy of Caves of MACA	W B White	Penn St U & CRF	6,7	4	
553	N-28	Reconnaissance Geology & Biology of New Discovery Section, MACA	W B White T L Poulson	Penn St U & CRF U Illinois	6,7	4,5	3

1	2	3	4	5	A	B	C
MACA - MAMMOTH CAVE NATIONAL PARK, KENTUCKY (continued)							
554	N-29	Characterization of Subclimax Plant Communities in Karst Areas	T C Barr, Jr J M Baskins	U Kentucky	6	4	7
555	N-31	Long-Term Plant Succession Study at Selection Local in MACA	A Faller		6,7	4	3
556	N-32	Karst Morphology & Hydrology of Central Kentucky Karst at MACA	F D Miotke	Geog Inst, U Hannover, Germany CRF	6,7	4	9
557	N-35	Niche Separation in Three Species of Cave Beetle	T R McKinney	U Kentucky	6,7	4	10
558	N-36	Ecology of the Nesphaenops-Hadenoecus Prey System	R M Norton	Yale U & CRF	6,7	4	7
559	N-37	Geology & Geomorphology of Floyd Collins Crystal Cave	A N Palmer	SUNY, Oneonta CRF	7	4	6
560	N-38	Pleistocene Paleoclimate in the Central Kentucky Karst	R S Harmon	McMaster U, Canada CRF	4,6	4	4
561	N-41	Study of Saltpetre in the Central Kentucky Karst	C A Hill C B Fliermans P M Hauer	CRF	6	4	4
562	N-42	Status of Endangered Indiana Bats *Myotis sodalis*	S R Humphrey	Florida St Mus, Gainesville		4	2
563	N-43	Resource Partitioning in Five Species of Carabid Beetles	T C Kane	U Cincinnati	6	4	2
564	N-44	Algae Survey of Selected Regions of Mammoth Cave	R Van Hoff	W Kentucky U	7	4	7
565	N-45	Cave & Karst North of the Green River	No Shore Task Force	Louisville, Kentucky	7	4	3
566		Ecology of Evolution of Cave Invertebrates, Esp Beetles	S B Peck G Carmody C Laing	Carleton U, Canada	4	4	8
567		Illinois Basin Carbonate Project	E R Pohl R G Browne J Baxter	W Kentucky U Illinois Geol Surv	6,7	4	5
568		Chemical Communication in Troglobitic Crayfish	E E Little	SUNY, Stoney Brook	6,7	4	5
	MONTEZUMA CASTLE NATIONAL MONUMENT, ARIZONA Visitors (M): 339.2. Gross Acreage: 841						
569		An Exploration of Montezuma Well, Arizona, Using SCUBA Gear	S Y Harmon	Arizona St U	7	4	8

1	2	3	4	5	A	B	C
MOMC - MOUNT MCKINLEY NATIONAL PARK, ALASKA Visitors (M): 425.5. Gross Acreage: 1,939,492							
570	N-10	Wolf-Caribou Winter Range		NPS, BLM Alaska Dept F & G	1,4,5	1,2,3	3
571	N-11	Caribou Migration		NPS	1,2	1	3
572	N-13	Sheep Census		NPS, Alaska Dept F & G U Alaska	2,5	1,3	3
573	N-14	Moose Range		NPS	1,2	1	3
574	N-15	Wolf Composition	G Haber	U British Columbia	1,6	4	3
575		MOMC Bibliography	F C Dean	U Alaska	1	4	3
576	N-18a	Geology of Mount McKinley NP	W G Gilbert	U Alaska	6	4	3
577	N-19a	Off-Road Use Impact	R Chapman	CPSU	1	4	3
578	N-21	Denali Highway Impact	D Tracy	CPSU	1	4	8
579	N-22	Cooperative Mammal Study	P Valkenburg	CPSU	1	4	3
580	N-23	Grizzly-Human Interaction	H C Downing	CPSU	1	4	3
581	N-25	Natural Resource Atlas	K Whitten	U Alaska	5	4	8
582		Moose Census	W Troyer	NPS	2	1	8
MORA - MOUNT RAINIER NATIONAL PARK, WASHINGTON Visitors (M): 1,495.5. Gross Acreage: 235,404							
583	N-3a	Elk Migration	park staff		1	1	4
584	N-4a	Effects of Elk on Ecosystem	C Driver	U Wash	6	4	4
585	N-6a	Elk Range & Food Habits	park staff		1	1	3
586	N-7a	Elk Inventory & Distribution	park staff		1	1	3
587	N-27	Subalpine Meadows	J Henderson	Oregon St U	1,7	4	5
588	N-47	Behavior & Ecology of the Hoary Marmot	D P Barash	U Wash	6	4	5
589		Snow Surveys	L B Laird	USGS, Tacoma	4	2	3
590		Project Crater, Phase III	E P Kiver W Kiver	E Wash St U Steele C, Cheney	6	4	6
591		Tiger Beetles of MORA	V C Clifford	U Wash	7	4	7
592		Terrestrial Snails & Slugs	B A Branson	E Kentucky U	7	4	7
593		Heavy Mineral Sed Analysis	C M Tedlund	U Puget Sound	7	4	7
594		Seismic Studies	N H Rasmussen	U Wash	6	4	3
595		Plant Checklist	I Cresco	U Puget Sound	7	4	7
596		Fungi of Northwest	F Van de Bogart Jr	U Wash	7	4	4

MORA - MOUNT RAINIER NATIONAL PARK, WASHINGTON (continued)

1	2	3	4	5	A	B	C
597		Tatoosh Igneous Intrusive	J R Dunn	U Pittsburgh	6	4	3
598		Biting Fly Survey	W J Turner	Wash St U	6	4	3
599		Eracaceae - Blueberry Disease	S S Stowell	U Wash	7	4	7
600		Slime Molds of MORA	S S Stowell	U Wash	7	4	9
601		Hot Spring Algae	D L Tyson	U Wash	6	4	
602		Aquatic & Staphynid Beetles	A Smetana	Agri Res Inst, Ottowa	6	4	
603		Trichoptera - Aquatic Beetles	D Peck	Ctrl Wash St C	6	4	
604		Lepidoptera of the NW	M D Buskirk	U Wash	7	4	7
605		Glacier Cave Insects, Fungi	C H Anderson	U Wash	7	4	8
606		Biosystematics of Corealorja	M I Moor	Chico St U	7	4	9
607		Taxonomy of Smelowskia	C W Greene	U Alberta	7	4	9
608		Characteristics of Alpine Glacier Tills	H H Mills	U Wash	6	4	8
609		Dragonflies of the Pacific States	D R Paulson	U Wash	7	4	3

MUWO - MUIR WOODS NATIONAL MONUMENT, CALIFORNIA
Visitors (M): 811.2. Gross Acreage: 553

1	2	3	4	5	A	B	C
610		The Status of the Spotted Owl in California		CA Dept F & G USFS & NPS	5	3	10
611		Environmental Influences of the *Sequoia sempervirens*	M A da Luz	City C of San Francisco	7	4	10
612		The Effects of Human Trampling in *Sequoia sempervirens*	S R Krenzelok	UC, Berkeley	7	4	10
613		Differential Rate of Redwood Pollen Destruction	J L Heid	San Francisco St U	7	4	8

NOCA - NORTH CASCADES NATIONAL PARK, WASHINGTON
Visitors (M): 885.3. Gross Acreage: 504,785

1	2	3	4	5	A	B	C
614	N-1	Slope Stabilization of Roads, Trails, & Barrow Pits	A Tiedemann	USFS	1	2	
615	N-2	Human Impact on Subalpine & Alpine Zones	E G Schreiner	U Wash	1	1,4	3
616	N-5	Botanical Inventory	R Naas D Naas		1,2	4,5	3
617	N-12	Effects of Fish Introductions on Montane Lakes	C R Wasem	NPS	2	1	4
618	N-13	Forest Fire Ecology	J Miller M Miller		1,2,7	5	3

1	2	3	4	5	A	B	C
NOCA - NORTH CASCADES NATIONAL PARK, WASHINGTON (continued)							
619	N-22	Mountain Lake Ecology	C R Wasem	NPS	2	1	4
620	N-23	Mountain Stream Ecology	C R Wasem	NPS	2	1	3
621	N-24	Reservoir Ecosystems Sport Fisheries	C R Wasem	NPS	2	1	3
622	N-38	Descriptive Ecology of Proposed Research Natural Areas	C Maser	USFS	1	2,4	3
623		Hepialid Moths & High Altitude Butterflies	N B Tindale	So Australia Mus	7	4	3
624		Plant Ecology Investigation of Big Beaver Valley	J Miller M Miller	Fed Power Comm	4	5	9
625		Revegetation of Impacted Areas at Cascade Pass	J Miller M Miller	Bellevue, Wash	2,7	5	3
626		Fisheries Research on Ross, Diablo, & Gorge Lakes & Streams	R Burguer L Doran	U Wash Slaney & Co, Vancouver	6	4,6	3
627		Pika Study	E O'Connor	U Wash	6	4	6
628		Fungi Taxonomy	F Van de Bogart Jr	U Wash	7	4	3
629		Origins of Gneiss	B W D Yardley	U Wash	6	4	
630	N-41	Human Impact on Ground Cover at Backcountry Camps	C R Wasem	NPS	2	1	3
631	N-42	Stabilization of Exposed Bed of Lake Chelan	C R Wasem	NPS	2	1	5
632		Rock Specimens for Structural Geology Thesis	W K Wallace	U Wash	6	4	
633		Survey of Predatory Birds	J Fackler		2,7	1	6
634	N-43	Browse Rejuvenation on Ross Lake Winter Deer Range	C R Wasem J Adkins	NPS	2,5	1,3	3
OLYM - OLYMPIC NATIONAL PARK, WASHINGTON Visitors (M): 2,479.3. Gross Acreage: 897,885							
635	N-15	Ecology & Management of Non-Native Mountain Goats	B Moorhead	OLYM	1	1	5
636	N-16	Management Studies of Human Impact	B Moorhead	OLYM	1	1	4
637	N-2	Human Impact in Alpine Ecosystems	E Schreiner	U Wash	1	1,4	5
638	N-7	Blue Galcier Studies	R R LaChapelle	U Wash	6	4	3
639	N-18	Forest Vegetation of OLYM	R Fonda	WWSC	6	4	3
640	N-23	Natural History Interpretation Coastal Zone	S Blau	U Wash	6	4	8

OLYM - OLYMPIC NATIONAL PARK, WASHINGTON (continued)

1	2	3	4	5	A	B	C
641		Ecology Alpine Timberline	R Fonda	WWSC	6	4	3
642		Feeding Habits of *Microtus* Rodents	R Fonda M Sheehan	WWSC	6	4	7
643		Ecology Olympic Marmot	R Fonda W Wood	WWSC	6	4	6
644		Ecology Phyllodoce Heather	I Olmstead	Duke U	6	4	8
645		Fish & Aquatic Organisms	R Mausolf	Peninsula C	6	4	3
646		Slime Molds	P A Zahl	Nat Geog Soc	6	4	3
647		Tree Increment Borings	C Switzer	Chimacum High Sch Peninsula C	6	4	3
648		Mosses	C G Manville	U British Columbia	6	4	3
649		Plants	C Schaack	U Montana	6	4	3
650		Tiger Beetles	D Sumlin	Riverside County Agri Comm Off	6	4	3
651		Rocks	A D Horn	U Wash	6	4	3
652		Fungi	F Van de Bogart Jr	U Wash	6	4	3
653		Insects	D Kavanaugh	CA Acad Sci	6	4	3
654		Insects	H Goulet	U Alberta	6	4	3
655		Plants & Insects	J Belsky	U Wash	6	4	3
656		Insects & Plants	G E Walthall	Beaverton High Sch	6	4	3
657		Plants, Rocks & Soil	E L Tisch	Peninsula C	6	4	3
658		*Pedicularis bracteosa*	M Roose	UC, Davis	6	4	3
659		Plants	M V Sheehan	WWSC	6	4	3
660		*Microtus oregoni* *Microtus longicaudus*	M V Sheehan	WWSC	6	4	3
661		Lepidoptera	D G Robinson	Nat Hist Mus, Dominican Republic	6	4	3
662		Slime Molds	S S Stowell	U Wash	6	4	3
663		Plants	L E Hedrick	Pomona C	6	4	3
664		Plants	M P Harthill	CA St Poly U	6	4	3
665		Rocks & Minerals	L Scott	Wash St U	6	4	3
666		Mushrooms	P Johnson M McCallam	Peninsula C	6	4	3

1	2	3	4	5	A	B	C
	OREGON CAVES NATIONAL MONUMENT, OREGON Visitors (M): 152.3. Gross Acreage: 465						
667	N-1A	Interrelationship of Light & Green Plants in Cave	J A Blaisdell H Curl	NPS Oregon St U	2	4	10
OZAR - OZARK NATIONAL SCENIC RIVERWAYS, MISSOURI Visitors (M): 1,428.4. Gross Acreage: 79,587							
668		Water Quality Study		USGS	2	2	7
669		River-Use Investigations		NPS	2	1	6
670		Floater Impact Study		U Missouri	2	4	7
671		Floater Sociological Study		So Illinois U	6	4	6
672		Wildlife Habitat Management		NPS Missouri Cons Dept	2,5	1,3	3
673		Fishery Investigations		NPS	2	1	3
674		Trout Stocking		Missouri Cons Dept	5	3	3
675		Floodplain Management		NPS	2	1	3
PAIS - PADRE ISLAND NATIONAL SEASHORE, TEXAS Visitors (M): 796.3. Gross Acreage: 133,918							
676		Beach Impact Study	E W Behrens	Marine Sci Inst U Texas	1	4	3
677		Tide & Circulation Study of Upper Laguna Madre	N P Smith	Marine Sci Inst U Texas	1	4	3
678		Effects of Human Activity on Ecology of Sand Dunes	J McAtee	Texas A & I U	1,6	4	8
679		Effect on Beach & Foredune Anthropods by Human Impact	A R Ortiz	Texas A & I U	1,6	4	8
680		Mammal Population, Species, & Energy Flow in Ecosystem	J T Baccus	Wiley C	6	4	6
681		Padre Island Biological Survey	J K Baker G Blacklock F Jones J Andrews H Hildebrand	NPS Welder Wildl Refuge Corpus Christi Texas A & I U	1,4	1,4,6	8
682		Ecological Research - Plant Succession & Management Unit Only	K Katner	Texas A & I U	6	4	10
683		The Use of Grasses for Dune Stabilization along Texas Coast	B Fall	Texas Tech Army Corps Eng	4	4	10
684		Research in Hormones Using Species of Holbrookia	J T Watson	U Texas, Houston	6	4	8
685		Levels of Organochlorines in Peregrin Falcons on PAIS	R Rogers	Texas Tech U	7	4	8

1	2	3	4	5	A	B	C

PAIS - PADRE ISLAND NATIONAL SEASHORE, TEXAS (continued)

1	2	3	4	5	A	B	C
686		Vegetation Distribution & Soils of Spoil Banks	C H Mendoza	Texas A & I U	6	4	8
687		Bird Nesting & Nesting Success on Spoil Banks	R R Ortiz	Texas A & I U	6	4	8
688		Recent Beach Sediments of Texas	D R Well	U Texas	6	4	8
689		Recent Beach Sediments of Texas	W L Foley	U Texas	6	4	8
690		Herbarium for Park	F B Jones	Welder Wildl Refuge, Sinton	7	4	10
691		Research on 7½ Fathom Reef off Padre Island NS	T Shirley D McCarty S Rabalais N Rabalais	Texas A & I U	6	4	7
692		Research on Ecology & Behavior of Land Crabs & Related Forms	L W Powers	Marine Sci Inst U Texas	6	4	6
693		Duck Food Study in Laguna Madre	H Hildebrand	Texas A & I U	6	4	7
694		Assessing Fishery Potential of Shore Zone of Texas	J McEachran	Texas A & M U	6	4	7
695		Herbarium Collection of Grasses for Park	B Fall	Texas Tech U	6	4	10
696		Study of Sand Migration through Dunes & Dune Complex	C C Mathewson	Texas A & M U	6	4	7
697		Determine Composition, Life History of Marine Fauna in Beaches	M Chittenden, Jr	Texas A & M U	6	4	7

PERRY'S VICTORY AND INTERNATIONAL PEACE MEMORIAL, OHIO
Visitors (M): 107.4. Gross Acreage: 25

1	2	3	4	5	A	B	C
698		Title I Services	Dalton Dalton Little Newport	Ohio St U	1	4,6	7

PEFO - PETRIFIED FOREST NATIONAL PARK, ARIZONA
Visitors (M): 789.2. Gross Acreage: 94,189

1	2	3	4	5	A	B	C
699		Microenvironment of Chinle Formation, PEFO, Arizona	T L Smiley	U Arizona	6	4	4

PICTURED ROCKS NATIONAL LAKESHORE, MICHIGAN
Visitors (M): 298.9. Gross Acreage: 68,958

1	2	3	4	5	A	B	C
700		Sleeping Bear Dunes & Pictured Rocks NL		U Michigan	1	4	10

1	2	3	4	5	A	B	C
	PICTURED ROCKS NATIONAL LAKESHORE, MICHIGAN (continued)						
701		Deer Management, Beaver Basin		No Michigan U	1	4	2
702		Glacial Geology	C Drexler	U Michigan	1	4	2
PINN -	PINNACLES NATIONAL MONUMENT, CALIFORNIA Visitors (M): 138.5. Gross Acreage: 14,497						
703		A Quantitative Ecological Study of the Woody Perennial Vegetation in Selected Stands of Oak-Savannah at Pinnacles NM	W H Brooks		2,7	4	5
PLAT-ARBU	PLATT NATIONAL PARK - ARBUCKLE RECREATION AREA, OKLAHOMA Visitors (M): 3,903.5. Gross Acreage: 911						
704	N-1	Subsurface & Surface Water Flows, Platt NP	J F Harp J G Laguros	U Oklahoma	1	4	
PORE -	POINT REYES NATIONAL SEASHORE, CALIFORNIA Visitors (M): 1,333.7. Gross Acreage: 65,297						
705	N-1	Ecological Wildlife Study, Deer		CA Dept F & G	5	3	6
706		Effect of Tillage on Diseases of Native Plants	C E Yarwood	UC, Berkeley	4,6	4	4
707		Population Ecology of Granivorous Birds	L R Mewaldt R M Stewart	Point Reyes Bird Observ	6	4	6
708		Marine Plants & Invertebrates of Seashore	R D Beeman	San Francisco St U	6	4	3
709		Food Habits of Marine Mammals of California	R E Jones	UC, Berkeley	6	4	3
710		Insect-Plant Interrelationships of Seashore	E I Schlinger P A Rauch	UC, Berkeley	6	4	3
711		Avifaunal Census of Limantour Estero	J Smail G Page	Point Reyes Bird Observ	6	4	3
712		Breeding-bird Census	R M Stewart	Point Reyes Bird Observ	6	4	3
713		Dominance Study of the White-crowned Sparrow	R M Stewart	Point Reyes Bird Observ	6	4	6
714		Nesting Study of the Orange-crowned Warbler	R M Stewart	Point Reyes Bird Observ	6	4	3
715		Population Biology of the Cladoceran Genus, *Daphnia*	L W Lee	UC, Berkeley	6	4	
716		The Role of Song Dialects in White-crowned Sparrows	M C Baker	Rockefeller U	6	4	
717		Predictive Systematics of Natural Populations (Birds)	R F Johnston W Klitz	UC, Berkeley	4,6	4	

1	2	3	4	5	A	B	C
PORE - POINT REYES NATIONAL SEASHORE, CALIFORNIA (continued)							
718		Marin Heronry Study	H M Pratt D Elliott	Point Reyes Bird Observ	6	4	
719		Genetic Similarity between Races of Gasterosteus	J C Avise	UC, Davis	6	4	
720		Beach Pseudoscorpions of Point Reyes	V F Lee	CA Acad Sci	6	4	
721		Intertidal Insects & Associated Plants of Seashore	R L Peterson	San Francisco St U	6	4	3
722		Biology of Bats at Point Reyes NS	J L Patton	UC, Berkeley	6	4	3
723		Population Studies of Marine Life, Point Reyes	G L Chan	C of Marin	6	4	
724		Survey of Tidepool Fishes in Point Reyes NS	M R Brittan	Sacramento St U	6	4	3
725		Insects in Relation to Controlled Burning	J P Anduiza	San Francisco St U	6	4	3
726		Vegetation Studies of the Bishop Pine Forest	C Rickard	San Francisco St U	6	4	6
727		Foraging & Social Behavior of Kinglets	R M Stewart	Point Reyes Bird Observ	6	4	6
728		Social Relations in *Neotoma fuscipes*	K Wallen	UC, Berkeley	6	4	7
729		Beach & Dune Vegetation of the Seashore	M G Barbour A Johnson B Holton	UC, Davis	6	4	3
730		Coastal Vegetation at Point Reyes NS	M T Morlin	San Francisco St U	6	4	7
731		Dating Stands of Douglas Fir	J M Eckert	UC, Berkeley	6	4	8
732		Insects of California	R L Langston C Henne E M Perkins	UCLA	6	4	8
733		Floristics of No California Mosses	S P Rae	UC, Berkeley	6	4	7
734		Ecology of Salticid Spiders	C E Griswold	UC, Berkeley	6	4	6
735		Algea of the Seashore	T R Pearson	UC, Davis	6	4	8
736		Lichens of Point Reyes NS	I M Brodo	Nat Mus Canada	6	4	8
737		Recycling of Shells in the Beach Strata	P A Wagner	Scripps Inst Oceanography	6	4	8
738		Sand Dune Fauna of Coastal California	J T Doyen C N Slobodchikoff	UC, Berkeley	6	4	3

1	2	3	4	5	A	B	C
REDW -	REDWOOD NATIONAL PARK, CALIFORNIA Visitors (M): 328.3. Gross Acreage: 62,304						
739	N-1	Ecology of the Coast Redwood	S D Veirs, Jr	REDW	2	1	6
740	N-3	Succession on Cutover Land	S D Veirs, Jr	REDW	2	1	5
741	N-5	Marine Survey	M J Boyd	Humboldt St U	2	4	6
742	N-8	Cooperative Remote Sensing Study	R W Thomas T F Hatzimanolis	For Remote Sensing Lab REDW	6	1,4	10
743	N-9	Dynamics of Prairie Vegetation	S D Veirs, Jr	REDW	2	1	4
744	N-11	Stream Monitor System Study	R W Janda	USGS	1	1,2	6
745	N-12	Water Quality Simulation Study	S M Zand	USGS	4	2	4
ROMO -	ROCKY MOUNTAIN NATIONAL PARK, COLORADO Visitors (M): 2,501.1. Gross Acreage: 263,792						
746	N-1c	Status of Bighorn Sheep	J A Bailey T Bauman	Colorado St U	1	4	3
747	N-2a	Survey of Aquatic Resources	D R Stevens J Mullan	NPS	1,4	1,2	3
748	N-5	Park Geology Map	W E Bates	NPS	7	1	3
749	N-6	Recovery of Alpine Tundra Systems Following Human Trampling	B Willard W Reid	CEQ Colorado U	7	4,5	3
750	N-8a	Ungulate Habitat Conditions & Trends	D R Stevens	NPS	1	1	3
751	N-12	Vegetation Community Studies	D R Stevens	NPS	1	1	3
752	N-13	Ungulate Ecology Study	D R Stevens	NPS	1	1	6
753	N-19	Fire Ecology	J Barrows E Mogren H Clagg	Colorado St U NPS	1,4	4	3
754	N-20	Greenback Trout Restoration	D R Stevens J Mullan	NPS	1,4	1	3
755		Ecology & Epidemiology of Vector-borne Diseases (Colorado Tick Fever)	R McLean A Barnes S Bowen B Francy	DHEW	4	2	4
756		Geology of Park	W Braddock J Cole J O'Neill	USGS Colorado U	4	2,4	3
757		Ecology & Population Dynamics of White-tailed Ptarmigan	C Braun		5	3	6
758		Responses of Elk to Human Disturbance	J A Bailey R Schultz	Colorado St U	1	4	7

1	2	3	4	5	A	B	C
ROMO - ROCKY MOUNTAIN NATIONAL PARK, COLORADO (continued)							
759		Analysis of Alpine & Subalpine Wind Conditions in Winter	D Glidden		2	5	10
760		Composition & Dynamics of the Forests of the E Slope of the Front Range	R K Peet	Cornell U	6	4	8
761		Study of Red-tailed Hawks	K Suhrbier		7	5	4
762		Autoecology of Kobresia	K Bell	U Alberta	6	4	10
763		Bird Study	A Collister R Esposito	Denver Mus Nat Hist	5,7	3,4	3
764		Passerine Birds in Alpine Tundra	R A Ryder	Colorado St U	6	4	6
765		Behavior of Rosy Finch	D F Shreeve	Cornell U	6	4	6
766		Ecology & Behavior of the Williamson Sapsucker	A B Crockett	Colorado U	6	4	6
767		Ecology of Insectivorous Birds in Montane Floodplain	R C Eckhardt	Cornell U	6	4	5
768		Soil Clay Mineralogy	D I Netoff	Lincoln C Illinois	7	4	6
769		Glacial Geology of W Slope	T C Meierding	Colorado U	7	4	5
770		Investigations of Volcanic Rocks	W N Sharp R B Taylor	USGS	4	2	10
771		Soil Genesis on Late Quaternary Moraines	R Shroba	Colorado U	6	4	8
772		Forest Trees of Colorado	G H Fechner	Colorado St U	7	4	8
773		Study of Carices	M F Colson	Colorado U	6	4	3
774		Behavior of Ground Squirrels	D Byman	Colorado U	6	4	6
775		Biology of Oligochaetes	D L Elrick	Colorado U	7	4	6
776		Study of Trichomycetes	R W Lichtwardt S I Moss J F Manier	U Kansas, Lawrence	6	4	3
777		Drought-resistance in Trees	G Fechner M Cline C P Reid L Hall	Colorado St U	6	4	5
778		Study of Aspen	C E Olmsted	Colorado U	7	4	4
779		Biosystematic Study of *Mentzelia*	R J Hill	U Wyoming, Laramie	7	4	3
780		Small Mammal & Bird Study	J J Hodge	Shiloh High Sch	7	4	3
781		Insect Study	R L Pederson G B Pederson	NPS	2	1	6
782		Geomorphology Study	W C Mahaney	York U Toronto, Canada	6	4	4

1	2	3	4	5	A	B	C
ROMO - ROCKY MOUNTAIN NATIONAL PARK, COLORADO (continued)							
783		Backcountry Use Attitudes	J R Fazio	Colorado St U	1	4	10
784		Small Mammal Behavior at Visitor Overlooks	T Trone	Colorado St U	4	4	7
785		Food Habits of White-tailed Ptarmigan	T A May	Colorado U	6	4	10
786		Ecological Interpretation of No Central Colorado	T L Cacek	Colorado St U	7	4	10
787		Serum Protein Polymorphisms in Salmonoid Fishes	R DeLong	Colorado St U	6	4	10
788		Ecological Studies in Alpine Willow Marshes	M A Heifner	Colorado St U	6	4	10
789		Distribution of Lichens on Douglas Fir & Subalpine Fir	L P Gough	Colorado U	7	5	10
790		Evaluation of Lake Pollution from Sediments	R C Wunderlich	Colorado St U	1	4	10
SAGU - SAGUARO NATIONAL MONUMENT, ARIZONA Visitors (M): 363.8. Gross Acreage: 78,988							
791	N-2a	Saguaro Ecology I	C H Lowe	U Arizona	1	3	8
792	N-3	Saguaro Ecology III	C H Lowe	U Arizona	1	3	8
793	N-4	Saguaro Ecology II	C H Lowe	U Arizona	1	3	8
794	N-6	Saguaro Ecology IV	C H Lowe	U Arizona	1	3	8
795	N-23a	Saguaro Establishment	W F Steenbergh	NPS	1	1	9
796	N-26	Saguaro Population Dynamics	W F Steenbergh	NPS	1	1	
797	N-5a	Rodent-Vegetation Relationships	R M Turner	USGS	4	4	3
798	N-10a	Javelina Survival - Weather Relationships	G I Day	Arizona Dept F & G	5	3	6
799	N-12	Geological Mapping of the Rincon Mountains	R L Dubois A Leger	U Oklahoma	6	4	3
800	N-13a	Saguaro Establishment Trends	R M Turner	USGS	4,6	2	3
801	N-17	Native Plant Diseases Survey	R Gilbertson	U Arizona	6	4	3
802	N-19a	Virus Diseases of Cacti & Other Native Plants	M R Nelson R Wheeler	U Arizona	5	4	4
803	N-20a	Taxonomy of *Erwinia carnegieana*	S M Alcorn	U Arizona	6	4	6
804	N-24	Bird Population Factors	S M Russell	U Arizona	6	4	4
805	N-28	Saguaro Height-Age Relationships	S M Alcorn	U Arizona	6	4	3

SAGU - SAGUARO NATIONAL MONUMENT, ARIZONA (continued)

1	2	3	4	5	A	B	C
806	N-37	Ordination & Quantitative Analysis of Perennial Vegetation	W H Brooks	Pima C, Tucson	6	4	8
807	N-39	The Ecology of Small Desert Rodents	C W Ogston	Princeton U	6	4	10
808	N-40	Analysis of Effects of Veg Parameters on Bird Sp Div	E Yensen	U Arizona	6	4	10
809	N-49	Phenological Studies of Desert Perennials	T W Yang	U Arizona	6	4	3
810	N-50	Structural Analysis of the Rincon Mountains	J Schloderer G Davis	U Arizona	6	4	9
811	N-51	Fold Analysis - Saguafo NM	G Davis	U Arizona	6	4	9
812		Rock Specimens	J Wilt		6	4	8
813		Clay & Other Earth Materials	M Myhrman		6	4	6
814		Rocks	R Varga		6	4	8
815		Insects & Arachnids	F Enders		6	4	8
816		Perennial Vegetation	W H Brooks		6	4	3
817		Plants, Animals, & Rocks	H T Coss		1	1	3
818		Plants, Animals, & Rocks	R Richards		1	1	3
819		Plants, Animals, & Rocks	T Lorig		1	1	3
820		Coyote Scats	R T White		6	4	8

SAJU - SAN JUAN ISLAND NATIONAL HISTORICAL PARK, WASHINGTON
Visitors (M): 68.3. Gross Acreage: 1,751

1	2	3	4	5	A	B	C
821		The Biology of the Rabbit *Orcytolagus cuniculus* in San Juan Island NHP & Vicinity	A R Weisbrod W F Stevens	USNPS, CPSU C For Resources, U Wash, Seattle	1,6	1,4	
822		Esturine Studies & Population Dynamics of Clams	V R Gallucci	U Wash, Seattle	6	4	
823		Investigations on the Nanoplankton in Jakel's Lagoon	R Norris R Pienaar	U Wash	6	4	
824		Population Dynamics & Production of the Marine Copedpod in Jakel's Lagoon	M R Landry	Dept Oceanography	6	4	
825		Zooplankton Populations in Jakel's Lagoon	K Banse	U Wash	6	4	

SKC - SEQUOIA AND KINGS CANYON NATIONAL PARKS, CALIFORNIA
SEQUOIA: Visitors (M): 686.9. Gross Acreage: 386,823. KINGS: Visitors: 1,224.4. Acreage: 2,884

1	2	3	4	5	A	B	C
826	N-1	Ecology of the Giant Sequoias	R J Hartesveldt H T Harvey H Shellhammer R E Stecker		1	4	8
827	N-6	Fire in the Mixed Conifer Forest	D J Parsons	SKC	2	1	3
828	N-7	Effects of Fire & Sodium-Calcium Borate on Chaparral Vegetation	S K Stocking	San Joaquin Delta C	1	4	3
829	N-9	Hydrological Studies of a Natural Burn	R C Averett	USGS	1	2	5
830	N-11	Ecology of a Natural Burn	J Villeponteaux	UC, Berkeley	1,2	4	
831	N-19	Kaweah River Studies	M J Zardus	SKC	1	1	3
832	N-26	Restoration of Natural Environment in Mixed Conifer Forest	B M Kilfore	NPS	2	1	8
833	N-27	Natural Fire Frequency Investigation	B M Kilfore	NPS	2	1	8
834	N-28a	Role of Fire in Chaparral	D J Parsons	SKC	2	1	3
835	N-30a	Carpenter Ants & Giant Sequoias	D Wood C David	UC, Berkeley	1	4	6
836	N-31	Black Bear Research	M White	UC, Berkeley	1	4	
837	N-35	Fire & Nutrient Status in Giant Sequoias	P W Rundel T St John	UC, Irvine	1	4	7
838	N-39	Backcountry Meadow Ecology	S DeBenedetti	Humboldt St C	1	4	8
839	N-40	Rae Lakes Study	D C Erman	UC, Berkeley	1	4	5
840	N-5a	Geology of Kings Canyon NP	J G Moore	USGS	4	2	3
841	N-8	Crystal Cave Survey	T Rohrer	NSS	7	6	
842	N-17a	Factors Important to Management of Mountain Meadows	P Zinke	UC, Berkeley	6	4	4
843	N-17b	Decomposition Rates of Meadow Herbage	R D Ratliff	USFS	4	2	6
844	N-33	Lilburn Cave & the Karst of Redwood Canyon	S Ulfeldt	NSS	7	6	
845	N-34	Vegetation Pattern within a Mixed Conifer--Sequoia	T M Bonnickson	UC, Berkeley	6,7	6	
846	N-36	Human Impact on High Altitude Lakes	G James	UC, Irvine	6	4	8
847	N-37	Black Oak Fire Ecology	J Sellers	Kingsburg High Sch	7	1,5	5
848	N-38	Isotopic Studies of Speleothems	P Thompson	CA Tech	6	4	

1	2	3	4	5	A	B	C
SKC - SEQUOIA AND KINGS CANYON NATIONAL PARKS, CALIFORNIA (continued)							
849		Kaweah Peaks Pluton & Its Relationship to Age of Kern Canyon Fault	J L Burnett	Div Mines, St CA	5	3	9
850		Preliminary Study of Sierra Nevada Bighorn Sheep	J Wehausen	U Michigan		4	7
851		Sierra Club Impact Studies	T Harvey	San Jose St U		4	7
852		Puma Survey	C Koford	UC, Berkeley	4	4	5
853		Spotted Owl Survey	G I Gould, Jr		4	3	10
854		Soil Fauna Studies	D W Price G S Benham, Jr	UC, Berkeley	4	4	7
855		Sarcodes	J W Taylor	UC, Davis	6	4	4
856		Golden Trout Research	G Gall	UC, Davis	4,5	4	7
857		Granitic Plutons	J Chen	UC, Santa Barbara	6	4	5
858		Genetics of Giant Sequoia	L Fins	UC, Berkeley	4	4	5
859		Ecology of Migration in Warblers (Parulidae)	R L Hutto	UCLA	7	4	5
860		Study of Monotropoideae	G Wallace	Rancho Santa Ana Bot Garden	7	4	5
SHEN - SHENANDOAH NATIONAL PARK, VIRGINIA Visitors (M): 2,215.3. Gross Acreage: 190,419							
861	N-13	Ecology & Population Dynamics of the Black Bear	J W Raybourne	Virginia Comm Game & Inland Fisheries	4,5	1,3	6
862		Aquatic Invertebrates	T Harshbarger	USFS			
863		Reptiles & Amphibians	W Witt	SHEN			
864		All Natural History Specimens	R Momich	SHEN			
865		All Natural History Specimens	P Elliott	SHEN			
866		All Natural History Specimens	D L Smith	SHEN			
867		All Natural History Specimens	E R Schaffner	SHEN			
868		All Natural History Specimens	J Meidell	SHEN			
869		Salamanders	R Jaeger	U Wisconsin			
870		Salamanders	R Highton	U Maryland			

1	2	3	4	5	A	B	C
	SLEEPING BEAR DUNES Visitors (M): unrecorded. Gross Acreage: 71,105						
871		Vegetation & Natural Features of So Manitou Island & Mainland	P Thompson	Cranbrook Inst Sci	1	4	10
872		Natural History Survey		U Michigan	1	4	10
873		Status of Gull Colony So Manitou Island	W E Southern	No Illinois U	1	4	5
	ST CROIX NATIONAL SCENIC RIVERWAY Visitors (M): 190.0. Gross Acreage: 35						
874		Inventory of St Croix & Namekagon Rivers	J Olin	U Minnesota	1	4	5
TICA -	TIMPANOGOS CAVE NATIONAL MONUMENT, UTAH Visitors (M): 226.6. Gross Acreage: 250						
875		Geomorphology of Timpanogos Cave System	D J Green		7	5	3
876		Algae of Timpanogos Cave System	L St Clair	Brigham Young U	6	4	9
877		Speleothem Growth in Timpanogos Cave System	A F Shelley		2	1	3
878		Visitor Impact on Air & Water of Timpanogos Cave System	A F Shelley		2	1	3
VIIS -	VIRGIN ISLANDS NATIONAL PARK, VIRGIN ISLANDS Visitors (M): 298.2. Gross Acreage: 14,470						
879	N-15B	Beach Processes Study	R Dolan S Hoffman A Robinson	U Virginia NPS, VIIS	1	1,4	10
880	N-12A	Underwater Visitor Impact	A Robinson	VIIS	1	1	3
881	N-12C	Impact of Effluents, VIIS	A Robinson	VIIS & Env Prot Agcy	1	1	8
882	N-12A	Coral Growth Rates - VIIS	A Robinson	VIIS	1	1	8
883		Aerial Surveys & Basic Underwater Resource Mapping	A Robinson	VIIS	1	1	3
884		Pesticide Residue Study	Reimold	U Georgia	6	4	10
885		Caribbean Frog Studies VIIS & Puerto Rico	Jones Dagenhardt	U New Mexico	4	4	8
886		Natural History Handbook	Philibosian-Intema	Virgin Islands Government	5	3	6
887		Reef Sediments	Feazel	Johns Hopkins U	6	4	9
888		Coconut Seed Studies	Diekert	Texas A & M U	6	4	9

1	2	3	4	5	A	B	C
VIIS - VIRGIN ISLANDS NATIONAL PARK, VIRGIN ISLANDS (continued)							
889		Bird Ectoparasites	N S Brown	Simmons C	6,7	4	6
890		Soil Myxbacteria	E Brockman	Ctrl Michigan U	6,7	4	7
891		Chironomid Study	L L Curry	Ctrl Michigan U	7	4	6
892		Plant Succession	C Mason	Gustavus Adolphus C	7	4	5
893		Pseudoscorpion Study	W B Muchmore	U Rochester	6,7	4	7
	VOYAGEURS NATIONAL PARK, MINNESOTA Visitors (M): 0.0. Gross Acreage: 219,128						
894		Eagle & Osprey Nesting Survey	L Grim	NPS	2	1	10
895		Vegetation Survey - Kettle Falls	L C Merriam, Jr	U Minnesota	1	4	6
896		Plant Virus Survey	E C Banttari	U Minnesota	6	4	3
897		Water Pollution Study		Minnesota Pollution Control Agcy	5	3	3
WHSA - WHITE SANDS NATIONAL MONUMENT, NEW MEXICO Visitors (M): 557.9. Gross Acreage: 145,334							
898	N-1	Origin & Development of Gypsym Dunes					
899	N-1a	Dissection & Analysis of Dune Structure		USGS & NPS	2,4	1,2	10
900	N-1b	Studies of Dune Movement		USGS & NPS	2,4	1,2	9
901	N-1c	Analysis of Wind Direction & Velocity		USGS & NPS	2,4	1,2	9
902	N-1d	Role of Hydrological Cycle		New Mexico Inst Mines & NPS	2,6	1,4	9
903	N-1e	Determination of Subsurface Composition & Structure		New Mexico Inst Mines & NPS	1,4	1,4	9
904		Sand Grain Comparison Study	W N Mack	Michigan St U	6	4	8
905		Reproductive Biology Study	R Spellenberg	New Mexico St U	6	4	4
906		Soil Composition Study	S Shannon, Jr	U Texas, El Paso	6	4	4
907		Insect Study	D Giuliani	CA Acad Sci	6	4	3
908		Insect Study	W Iselin	New Mexico Dept Agri	5	3	3
909		Reproductive Biology Study	R Delson	New Mexico St U	6	4	8
910		Sand Study	R Tucker	Wash St U	6	4	8
911		Japanese Beetle Study	W Iselin	New Mexico St U	6	4	3

1	2	3	4	5	A	B	C
WICA - WIND CAVE NATIONAL PARK, SOUTH DAKOTA Visitors (M): 855.7. Gross Acreage: 28,060							
912		Wildlife Range Conditions & Carrying Capacity		NPS & SCS	2,4	1,2	3
913		Master Cave Map	H Conn J Conn		1	5	7
914		Report on Wind Cave NP Grassland Ecology	R Gartner	So Dakota St U, Brookings	1	4	6
915		Prairie Dog Ecology Research	A L Lovaas	NPS	1	1	3
916	N-3	Metabolism of Prairie Dogs	G F Lund	U Iowa, Iowa City	6	4	3
917	N-11	Social & Breeding Behavior of the Pronghorn		Env Sci Ctr, Kananskis U Calgary, Alberta, Canada	6	4	6
918	N-12	Tagging of Elk Calves to Determine Distribution & Organization of the Elk Population within Wind Cave NP		Iowa Coop Wildl Res Unit, Ames	2,4	2	6
YELL - YELLOWSTONE NATIONAL PARK, WYOMING - MONTANA - IDAHO Visitors (M): 1,937.8. Gross Acreage: 2,219,822							
919	N-3a	Ecology of Gallatin Elk & Range Relationships		Montana Dept F & G USFS & NPS	1,5	1,3	3
920	N-6a	Behavior of Hydrothermal Features in Firehole Geyser Basin	R Hutchinson	NPS	2	1	3
921	N-8b	Bison Ecology	M Meagher	NPS	2	1	3
922	N-29a	Ungulate Ecology - YELL	D B Houston	NPS	2	1	3
923	N-38	Animal Ecology Studies	G Cole	NPS	2	1	3
924	N-39	Plant Ecology Studies	D Despain	NPS	2	1	3
925	N-41	Aerial Photography to Define Vegetation	D Despain	NPS	2	1	6
926	N-66	Bald Eagle & Osprey Population Status, Trends & Ecology	R L Eng	Montana St U	2	4	5
927	N-70	Systematic Investigations of Indigeneous Trouts of NPS	R Behnke	Colorado St U	2,4	4	7
928	N-72	Human-Wildlife Interaction in Yellowstone NP	H D Picton	Montana St U	2	4	7
929	N-73	Population, Status & Ecology of Grizzly Bears in YELL & Vicinity	R Knight	NPS	2,4	1	3
930	N-74	Food Habits of Grizzly Bear in YELL & Vicinity	H D Picton	Montana St U	2	4	6
931	N-75	Climatology, Grand Teton & Yellowstone NP	R Dirks	U Wyoming	2	4	5

1	2	3	4	5	A	B	C
YELL - YELLOWSTONE NATIONAL PARK, WYOMING - MONTANA - IDAHO (continued)							
932	N-76	Remote Sensing of the Molly Islands White Pelican Breeding Colony, YELL	K L Diem	U Wyoming	2	4	
933	N-78	Geophysical Sounding for Subsurface Magma	G P Eaton	USGS	4	2	
934	N-79	Research to Establish Whether or Not Magma Chamber Is Present under Yellowstone Caldera & Its Extent	R G Daniel	Stanford U	4	4	6
935	N-80	Ecology of Aquatic Birds on Yellowstone Lake	R L Eng	Montana St U	2	4	9
936	N-81	Reproductive Biology of Trout in a Thermally Enriched Environment: The Firehole River of YELL	C Kaya	Montana St U	4,6	4	6
937	N-16b	Biotic Succession of Lodgepole Pine Forest of Fire Origin in Yellowstone NP	D L Taylor	Sterling C	6	4	5
938	N-18a	Basic Stream & Lake Inventory - All Waters of YELL			4	2	3
939	N-44	Impact of Uncontrolled Mountain Pine Beetle in Lodgepole Pine	W Klein	USFS	4	2	4
940	N-49	Microbial Ecology of Thermal Environments	T Brock	U Wisconsin	4	4	3
941	N-53	Trophicdynamics of Thermal Spring Ecosystems	R Wiegert	U Georgia	4	4	6
942	N-65	Population Structure & Growth Rate of Sagebrush Lizard	R E Moore	Montana St U	6	4	3
943	N-71	Condition for Depth Hoar Formation	C C Bradley	Montana St U	4	4	7
944	N-82	Preliminary Investigation into the Zooplankton of Yellowstone Lake	J C Scott	U Nebraska	7	4	7
945	N-45	Pollen & Plant Macrofossils from Late Pleistocene Sediments in YELL	R G Baker	U Iowa	4	4	10
946		Development of a Habitat Type Classification for Forested Regions in Montana	S F Arno	USFS	4	2	8
947		Study of Algal Communities in Yellowstone River	L L Bahls	Montana Env Quality Council	5	3	6
948		Parasites of Ungulates, Teton NP & Adjacent Area	R C Bergstrom	U Wyoming	6	4	5
949		Studies of Thermophilic Microorganisms	R W Castneholz	U Oregon	4	4	6

YELL - YELLOWSTONE NATIONAL PARK, WYOMING - MONTANA - IDAHO (continued)

1	2	3	4	5	A	B	C
950		Sedimentary Structures Associated with the Petrified Forests of Yellowstone Park	A V Chadwick	Loma Linda U	6	4	5
951		Sedimentary Structures Associated with the Petrified Forests of Yellowstone Park	H G Coffin	Andrews U	6	4	8
952		Petrological Studies, Yellowstone Plateau Volcanic Rocks	R L Christiansen	USGS	4	2	5
953		Palynology of the Fossil Forest of Yellowstone Park	L H Fish P DeBord	Loma Linda U	6	4	6
954		Thermal Water/Soil Samples	H F Foerster	Sam Houston St U	7	4	6
955		Study of Sedimentology, Geochemistry & Natural & Man-caused Heavy Metal Pollution	J H Goodwin	U Utah	4	4	6
956		Parasites	R A Heckmann	Brigham Young U	6	4	5
957		Study Using X-Ray Diffraction Crystallography of the Changes in Volcanic Residues & Interaction with Forest Products	I G Holmes	Loma Linda U	7	4	5
958		Comparison with Algae from Hypersaline Lagoon in Baja	R J Horodyski	UC	4	4	8
959		Homing in Cutthroat Trout	L A Jahn	W Illinois U	6	4	7
960		Study of Bacteria in Hot Springs	J McGillis	Salt Lake City	7	6	3
961		Research on Ecology of Thermal Basins	R P Sheridan	U Montana	4	4	7
962		Acoustic-Magnetic Studies, Yellowstone Lake. Earthquake Monitoring, Yellowstone-Hebgen Lake Region	R B Smith	U Utah	4	4	5

YOSE - YOSEMITE NATIONAL PARK, CALIFORNIA

Visitors (M): 2,343.1. Gross Acreage: 761,093

1	2	3	4	5	A	B	C
963		Post Glacial Pollen Records	J R Botch	CA St U, San Francisco	6	4	8
964		Geologic Map, Tuolumne Meadows	P C Bateman	USGS, Menlo Park	4	2	5
965		Meadow Boundary Factors	K E Bouche	UCLA	6	4	10
966		Ecological Niches of Chipmunks	H E Broadbrooks	So Illinois U	6	4	3
967		Geology of Saddlebag Roof Pendant	C E Brooks	USGS, Menlo Park	6	4	9
968		Air Quality Determinations	J J Carroll	UC, Davis	6	4	3
969		Evaluation of Ranids	S M Case	UC, Berkeley	6	4	3
970		Systematics of *Aliatupus*	F A Coyle	W Carolina Acad	6	4	3

1	2	3	4	5	A	B	C
YOSE - YOSEMITE NATIONAL PARK, CALIFORNIA (continued)							
971		Human Impact on Wood Supplies	W B Davilla	CA St U, San Jose	6	4	3
972		McClure Glacier Study	W W Dean	USGS, Menlo Park	4	2	10
973		Ecological Impact of Rock Climbing	C E Douglas	Fairfax, CA	7	5	3
974		Plant Reproductive Changes with Altitude	D A Douglas	UC, Berkeley	6	4	5
975		Monographic Review of *Lupinus*	D B Dunn	U Missouri	6	4	3
976		Snowfield Arthropods	D Durbin	CA St U, San Francisco	7	4	6
977		Soil Temperatures under Campfires	D B Fenn	NPS	1	1	8
978		Genetic Variation in *Sequoia*	L Fins	UC, Berkeley	6	4	3
979		Ecological Processes & Human Use	T C Foin	UC, Davis	6	4	3
980		Lodgepole Encroachment	R A Giffen	Me For Serv	7	3	3
981		Spotted Owl Status Survey	G I Gould	CA Dept F & G, Sacramento	1	3	10
982		Detection of Forest Insects	R C Hall	Nat Res Mgt Corp, Eureka	4	6	8
983		Population Study of a Granite Dome	L Jacobs	UC, Santa Barbara	6	4	3
984		Ecological Study of *Nibrinii*	D H Kavanaugh V Alberta Edmonton		6	4	3
985		Lodgepole Needleminer Ecology	T W Koerber	PSWFRES, Berkeley	4	2	3
986		Singleleaf Pinyon Ecology	R W Ladd	Columbia C, CA	6	4	3
987		Management of Human Components	R G L-e	UC, Berkeley	6	4	8
988		Asymetric Glacier Flow	C S McCarthy	UCLA	6	4	6
989		Taxonomy of *Allium*	D W McNeal	U Pacific, Stockton	6	4	3
990		High Sierra Plant Chemicals	E McMurry	UC, Santa Cruz	6	4	6
991		Pollination Ecology	L W Macior	U Akron	6	4	6
992		Mixed Conifer Simulation Model	J Menke	UC, Berkeley	1	4	7
993		Diurnal Drift of Odonata	D R Menick	Westmont C, Santa Barbara	6	4	8
994		Paiute Trout Restoration	T S Mills	CA Dept F & G, Fresno	5	3	3
995		Precipitation Distribution	D L Morgan	CA St U, Fresno	6	4	3
996		Environmental Effects on Dyslexia	H W Monroe	New Hampshire C	6	4	3

1	2	3	4	5	A	B	C
YOSE - YOSEMITE NATIONAL PARK, CALIFORNIA (continued)							
997		Gravimetry of the Sierras	H W Oliver	USGS, Menlo Park	4	2	3
998		Archaeological Overview	L W Napton	CSC, Stanislaus	1	4	6
999		Trail Revegetation Study	R Palmer	UC, Davis	1	4	8
1000		Bear Identification Study	J R Parmeter	UC, Berkeley	4	4	8
1001		Campsite Impacts	J R Parmeter	UC, Berkeley	1	4	6
1002		*Fomes Annosus* Evaluation	J R Parmeter	UC, Berkeley	4	4	3
1003		Metals in Natural Systems	C C Patterson	CA Tech, Pasadena	4	4	3
1004		Geologic Map, Yosemite NP	D L Peck	USGS, Wash	4	2	3
1005		Research Reserve	F E Sampson	Belmont, CA	7	5	3
1006		Ecol Req Mule Deer	A B Sansum	NPS, Yosemite	2	1	3
1007		Carnivore Status Survey	P F Schempf	UC, Berkeley	1	4	10
1008		Benthic Animals in Tuolumne	C J Tiernan	UC, Berkeley	1	4	10
1009		Clark's Nutcracker Behavior	D F Tomback	UC, Santa Barbara	6	4	6
1010		Backcountry Carrying Capacity	J W van Wagtendonk	NPS, Yosemite	1	1	3
1011		Geologic Map, Tower Peak	C Wahrhaftig	UC, Berkeley	4	6	3
1012		Study of Monotropoideae	G D Wallace	RSABG, Claremont	4	4	3
1013		Biosystematics of *Neuchara*	E F Wells	U No Carolina, Chapel Hill	6	4	3
1014		Vertebrate Debris Reduction	H G Weston	CA St U, San Jose	6	4	6
1015		Black Bear Ecology	M White	UC, Berkeley	1	4	6
1016		Visitor Use of Shuttle Buses	A W Wicker	Claremont Grad Sch	4	4	8
1017		Stratigraphy of Meadows	S Wood	CA Tech, Pasadena	6	4	8
1018		Exfoliation Study	W Holman	UCLA	6	4	8
ZION - ZION NATIONAL PARK, UTAH Visitors (M): 941.3. Gross Acreage: 146,571							
1019	N-1	Ecological Wildlife Study & Status of Zion Deer Herd	B B Moorehead	Utah St U	1,6	1	8
1020	N-2	Ecological Wildlife Study Bighorn Sheep Restoration Project	H E McCutchen	NPS	1,4	1	5
1021	N-17	Range Site-Soils Correlation	L Mason	USDA Soil Cons Serv	4	2	5

NARRATIVE REPORTS

These are reports of ongoing studies. They are not a part of the scientific literature and should not be quoted without prior consultation with the investigators.

UNIVERSITY OF ALASKA

UNIVERSITY OF ALASKA: REPORT ON THE SECOND YEAR'S ACTIVITIES
(CONTRACT NO. CX-9000-4-0038)

SUMMARY OF PROGRESS: The second year in the life of the Alaska Cooperative Park Studies Unit (CPSU) has been busy and eventful. Contracts totaling nearly one-third of a million dollars have come through the CPSU office during FY 1974. Much of this money was for projects being conducted on behalf of the Alaska Task Force in connection with the D-2 Lands Surveys elaborated below. Unit Leader Dean spent at least half time working on business; there were six graduate students who worked through the unit for at least a part of the fiscal year.

The basic contract for the operation of the unit set out five principal tasks:

1. To provide for the continuation of the Cooperative Park Studies Unit at the University of Alaska, College, Alaska.

2. To provide for the services of Frederick C. Dean as Unit Leader to an extent equaling at least one-half time.

3. To provide for work on at least the following specific project cases:

    a. An ecological evaluation of the impact of recent changes in the use of the Mount McKinley road on aspects of the park ecosystem.

    b. Continued bioecological survey of the proposed north extension of Mount McKinley National Park.

    c. Continuation of the study role of scavenging in the ecology of birds and mammals.

    d. Initiation of a study of the production ecology of willow (*Salix* spp.) and the relation of willow production to browse consumption by moose in Mount McKinley National Park.

    e. Continuation of the work on the bibliography and the wildlife data file.

4. To provide consulting services to the Alaska Task Force, Alaska State Office, Pacific Northwest Region and other offices of the National Park Service.

5. To provide teaching and research coordinated studies by continuing the teaching and research assignments of other government scientists and students in the CPSU at the University of Alaska.

Katmai National Monument. Field Assistant, Samuel Bemis, was assigned to work with Biologist Dennis in Katmai during the summer of 1973. The unit has contracted to computerize a bibliography for Katmai; work on this began in the fall of 1974. No other activity.

Glacier Bay National Monument. The unit provided administrative services for the Dixon Harbor Biological Survey contract. Unit Leader Dean attended a Dixon Harbor data review and planning session in Seattle in January. The second contract for this area (Dixon Harbor Environmental Studies) promises to be considerably more time-consuming both because of its larger magnitude and because of the increased number of transactions involved. This is a good example of the difficulty in providing really adequate service if contracts are let within a few weeks of the beginning of field work. Biologist Streveler can attest to some of the problems that he has had in making purchases on short notice through the university system. It would not have been so bad if the contract had been set up some months in advance.

The final report on the summer studies at Dixon Harbor has been filed with the Regional Chief Scientist. The unit has contracted to computerize a bibliography for Glacier Bay; work on this started in September.

Mount McKinley National Park. Because of McKinley's closeness and the past history of research done on grizzlies there by Dean, a good deal of attention has been given to this area. Tracy's project on the impact of traffic on wildlife distribution and behavior ran through the full field season in 1973; she was in the park again by late May 1974. Graduate student Patrick Valkenburg is initiating a thesis program aimed at determining the amount and nature of use of the north boundary area by grizzly bears. He is being assisted during the summer field season by graduate student Magoun; together they will gather detailed notes on birds, mammals, and plants. Following the 1974 field season we should be able to put together a fairly thorough report on the main biological features of the north boundary region. Valkenburg is not expected to complete his thesis until some time after the spring of 1975.

Nearly a week during August 1973 was spent in the preparation of a Resources Management Plan draft for Mount McKinley National Park. Unit Leader Dean and several of the unit students participated in the week-long session.

Aerial surveys made by the CPSU personnel in McKinley during the past fiscal year primarily were concentrated in the spring of 1974 in connection with bear denning and movements. A particular attempt was made to determine the extent of bear movements onto the north boundary region and the extent of denning activity in the north boundary region. The effort was frustrated to a considerable extent because of light snowfall and poor tracking conditions in that area. Copies of the individual flight reports for most of these flights have been filed at park headquarters. Mention was made above of the continued work on the park bibliography, wildlife data file, and the computerized base map.

Sitka National Monument. No activity.

D-2 Lands Surveys. The Chukchi-Imuruk Biological Survey was operated through the CPSU. It involved a fairly high level of secretarial, accounting, and expediting help. Any project involving a half dozen or more people seems to produce a considerable amount of work in staging and, unless they are cut off from their base while in the field, problems develop that need servicing through the field season. The final report for this project was unduly delayed, but it has finally been submitted. It promises to be a valuable contribution to our knowledge of this area.

The Gates of the Arctic area was surveyed floristically by David F. Murray and his wife, Barbara. They have submitted reports on the plants found; a number of very interesting records resulted from their work. The area studied constituted a transect across the Brooks Range. The work should be particularly valuable because of this north-south transect.

Publications

Dean, F. C., and D. L. Chesemore. Studies of birds and mammals in the Baird and Schwatka Mountains, Alaska. Biological papers of the University of Alaska. In press.

Dean, F. C. 1974. Aspects of grizzly ecology in Mount McKinley National Park. Paper presented at Third International Conf. on Bear Research and Management, Binghamton, N. Y. In press.

Dean, F. C. Wildlife aesthetics and management problems in Mount McKinley National Park. Presented to graduate seminar in Wildlife Management, University of Alaska, 5 February 1974.

Melchior, H. (ed.). 1974. Final report of the Chukchi-Imuruk Biological Survey. To be submitted to Biological Papers of the University of Alaska.

Streveler, G. P., I. A. Worley, C. J. Terry, and R. J. Gordon. 1974. Dixon Harbor Biological Survey final report on the summer phase of 1973 research.

# # #

APOSTLE ISLANDS NATIONAL LAKESHORE

BEAR ISLAND ECOSYSTEM ANALYSIS

INVESTIGATORS:	Robert T. Brown) William Kowalski) William Larsen) Robert Schulz)	Michigan Technological University

SUMMARY OF PROGRESS: Three masters degree candidates spent the summer of 1974 on Bear Island (about 1800 acres). They are working out the detailed ecology of the island that can be used to develop as good a recreational use plan as possible before any trails or campsites are established. Part of the time they worked as a team and part of the time as individuals.

William Kowalski worked with the soils. He laid out 3 transects and dug 30 soil reference pits designed to sample all of the topographic and geologic land forms. Between these transects he laid out auger transects and made 6 ft soil cores at 100 m intervals along the line. Additional borings were made wherever the geology or topography changed. He took complete notes on each of the 300 auger sampling points and collected reference samples from each of the 30 pits. From these data he has identified at least 17 soil types. Stephen Shetron, a qualified soil scientist, visited the island, identified five of the soil types, and verified methods used in the soils work. In addition Kowalski mapped abandoned logging trails.

William Larsen made a careful survey of the vegetation on the island. He laid out a grid covering the island, the lines of which were spaced every 200 m, and placed a plot 20 m on each side at each grid line intersection, for a total of 154 plots plus 4 plots in special vegetation types not represented by grid line intersections. On each plot, all trees were recorded by species and dbh. He laid out shrub and sapling plots 4 m on a side--one in each corner of each large plot recording each species. Ground cover plants were recorded in meter square plots. Each of these was divided into 1/25 m^2 units and abundance of cover vegetation recorded as the number of sub-plots in which each species was rooted--a range from 0 to 25. In addition, a species list for each larger plot and for the island was made.

Robert Schulz studied the animals. He made species lists of mammals, birds, reptiles, and amphibians. To map the breeding bird territories he set out three 8 ha plots in different forest types and one 4 ha plot in a bog. He live-trapped animals smaller than red squirrels in eight 1 ha plots. Each captured animal was recorded, toe marked, and released. recapture data enabled estimation of populations. Red squirrel populations were estimated on six plots using a modification of the King census method. Numbers of hares and deer were estimated by pellet counts on the plots established by Larsen.

Results: At present, data are being collated and correlated for use in the construction of maps. Information being presented on maps includes:

1. soil types;
2. slope, aspect, and other topography;
3. depth to bedrock;
4. abandoned trails and roads;
5. vegetation;
6. environmental gradients;
7. breeding bird territories;
8. animal distribution;
9. recreational suitability; and
10. site development.

Additionally, the theses will include correlations between soil types, vegetation composition, animal populations, depth of bedrock, topography, and perhaps other features.

RECOMMENDATIONS: It is recommended that this project be continued to include the rest of Apostle Islands National Lakeshore. Future work can proceed more rapidly since we have worked out methods and know the area much better than at the beginning. Other islands will not have to be sampled as thoroughly because we can transfer our findings from Bear Island with confidence when we have taken representative samples in other parts of the lakeshore.

# # #

GULLS AND TERNS AS INDICATORS OF MAN'S IMPACT UPON LAKE SUPERIOR

INVESTIGATORS:	James T. Harris) Sumner W. Matteson)	Univeristy of Wisconsin, Madison

SUMMARY OF PROGRESS: We completed a census of all nesting Herring and Ring-billed Gulls and Common Terns on the Wisconsin shore of Lake Superior, including numbers and locations of breeding pairs and reproductive success.

We completed investigation of human activities within the national lakeshore and along the Wisconsin shoreline that affect these bird populations.

We drafted recommendations for management of critical areas for three species.

We found about 1010 nesting pairs of Herring Gulls, almost all within the national lakeshore.

We found 10-20 nesting pairs of Ring-billed Gulls within the large Herring Gull colony on Gull Island.

Common Terns nested only within Chequamegon Bay and Duluth-Superior harbor--both groups of colonies require special management.

Human disturbance at the nest colonies could adversely affect Gulls and Terns, particularly within the national lakeshore as it receives increasing numbers of visitors.

RECOMMENDATIONS: We recommend restrictions on human activity near five Herring Gull colonies within the lakeshore--on Gull, Eagle, Otter, and Hermit islands and on the point east of Squaw Bay.

The present study will be completed as planned in late January; we recommend follow-up studies.

# # #

FOREST HISTORY OF PICTURED ROCKS AND APOSTLE ISLANDS

INVESTIGATOR: Lawrence Rakestraw
Michigan Technological University
Houghton, Michigan

SUMMARY OF PROGRESS: Introduction: In many ways, Isle Royale, the Apostle Islands, and Pictured Rocks have a common history. The French and English explorers, fur traders, and missionaries followed the voyageur's highway along the south shore of Lake Superior. They marveled at Pictured Rocks, and very early used Chequamegon Bay as a harbor of refuge and a center of fur trade. As the fur trade declined, fishing took its place, first as an activity of the American Fur Company, then as centers of fresh water fisheries. Unlike Isle Royale, mining was never a major industry in either the Apostle Islands or Pictured Rocks. Quarrying was important in three of the Apostle Islands from about 1868 to 1910 but in the Pictured Rocks area mining was limited to the 1772 search for silver at Miner's Bay. Scientific exploration began after the war of 1812, with geologists and natural historians and ethnologists coming into the area. These include the expeditions of Louis Cass, Henry Schoolcraft, Henry W. Bayfield, Douglas Houghton, D. D. Owen; the later surveys of Foster and Whitney in Michigan; and the work of the state geological surveys after the Civil War. Agriculture began on a limited scale ~~in~~ the Apostle Islands about 1872, and lumbering about the same time. It began with "highgrading" white pine until the turn of the century, and then logging for other species until 1953. In the Pictured Rocks area, factors of geographical location and lack of harbors delayed lumbering until a comparatively late date. Tourism began in the Apostle Islands about 1890, with the establishment of resorts on Sand Island and Madeline Island. In the Pictured Rocks area it centered around Munising and Grand Island, also beginning about 1890. The movement to create a national park began in the Apostle Islands about 1928. The initial movement failed; state parks and forests were established, and the national park movement again gained momentum about 1956. The roots of the Pictured Rocks movement have not been explored.

Three areas outside the jurisdiction of the National Park Service were important in development of the areas under study. These are Grand Island and Munising; Grand Marais; Bayfield and LaPointe. Grand Island became the center of economic life on the west flank of Pictured Rocks, and later Munising became the headquarters of the Cleveland Cliffs operation. Grand Marais, at the eastern end of the Pictured Rocks area, was the center of fishing and lumbering activity. Madeline Island and its chief settlement, LaPointe, became the headquarters for American Fur Company's fur trading and fishing activity. Bayfield was the center of the fishing activity that developed after the Civil War and also the headquarters of lumbering and tourism. We are fortunate in having good urban histories of these areas (Castle 1974; Carter 1971; Burnham 1974; Ross 1971) which relate the cities to their economic hinterlands.

Summary of Field Work: Unseasonably bad weather prevented as much progress in field work as was anticipated. In the Apostle Islands, work was confined to Madeline Island where sites of the old settlement were visited; Basswood Island, where the quarries were given a detailed examination; Hermit Island, where the quarry was examined; and Stockton Island, where examination was confined to the campground. In the Pictured Rocks area, Miner's Castle and Miner's Bay were visited. Hopefully, next spring visits can be timed with the field work of the NPS staff.

Summary of Archival and Library Work: Library work included use of the resources of Michigan Tech, Marquette Historical Society, Northland College, Vaughan Public Library (Ashland), the library of the Minnesota Historical Society (St. Paul), and the University of Minnesota Forestry Department. Archival material was used in the Vaughan Library, Northland College, and microfilm copies of NPS and BLM records were obtained from Washington, D. C.

Research Completed or Partly Completed:

1. Early travel and exploration, 1660-1840.
2. Fur trade activity of American Fur Company at Grand Island and LaPointe.

3. Missionary activity at LaPointe.
4. Geological Surveys.
5. General Land Office Surveys.
6. History of Apostle Islands brownstone quarries.
7. Examination of land records of Register and Receiver, Pictured Rock area.
8. History of the fisheries.
9. History of lumbering, Apostle Islands.
10. 1928-30 national park movement, Apostle Islands.
11. Preliminary vegetation studies and fire history studies.

# # #

FLORISTICS AND VEGETATION OF THE APOSTLE ISLANDS

INVESTIGATORS: Rudy G. Koch) University of Wisconsin-Superior
Donald W. Davidson)

SUMMARY OF PROGRESS: To date, collections of plants on Basswood Island are complete except for the late fall flora. Vegetational analysis will be completed on a visit during early September of next year. The collections are not yet worked up but a species list will be available in 12 months. Aerial photos of the island have been completed. Only one visit was made to Stockton Island and those collections are currently being examined. A number of additions to the species list will be possible. Work on Long Island (adjacent to but not part of the Apostle Island National Seashore) is about half completed.

Considering the level of support, the work sequence is more or less on schedule. For completion of the entire project, travel and support monies will aid in expediting the work.

# # #

ASSATEAGUE ISLAND NATIONAL SEASHORE

ANALYSIS OF OVERWASH ON ASSATEAGUE ISLAND

INVESTIGATOR: John S. Fisher
University of Virginia

SUMMARY OF PROGRESS: The initial stages of this study, i.e., the general identification of the overwash process, should be concluded this year and presented in Stephen Leatherman's doctoral dissertation. This study will analyze the impact of individual storm/overwash events on the island.

With this basic information, the more complex questions concerning the stability of the dune system and its interaction with the eroding beach will be addressed. The phase of the study will require several years as well as research support. This support is presently being solicited.

# # #

A STUDY OF AUTUMN MIGRATIONS OF PEREGRINE FALCONS AT ASSATEAGUE ISLAND

INVESTIGATOR: F. Prescott Ward
Biomedical Laboratory, Edgewood Arsenal

SUMMARY OF PROGRESS: The results of the 1974 annual autumn survey of migrating Peregrine Falcons on Assateague Island, MD and VA were disappointing. We sighted 57 falcons and captured 27 of these for banding, of which 22 were different birds (i.e., 5 recaptures). The sighting totals were the second poorest of the 5-year, annual fall study. The investigation is proving to be a rather sensitive index to annual reproductive success of this endangered species and should be continued at the present level of effort each autumn.

No avian specimens were collected other than prey feathers from falcon kills, or dead, sick, or injured birds salvaged for the U.S. National Museum of Natural History.

# # #

ECOTYPIC DIFFERENTIATION OF *SPARTINA PATENS* POPULATIONS ALONG A LATITUDINAL GRADIENT WITH PARTICULAR REFERENCE TO PLASTICITY

INVESTIGATOR: John M. B. Brodhead
University of Massachusetts

SUMMARY OF PROGRESS: *Spartina patens* collected at Assateague Island National Seashore is being grown under controlled environment conditions in the Botany Department Growth Chambers. It will be compared for photosynthetic rates and gross growth rates with plants of *S. patens* collected from the Gulf Coast and Atlantic Coast from the Florida Keys to Newfoundland.

To date the main work has involved collection from other sites, stabilization of all populations under extended greenhouse growth, and extensive vegetative propagation to obtain material of identical genetic origin.

# # #

BANDELIER NATIONAL MONUMENT

REPRODUCTIVE STATUS OF ALLIGATOR JUNIPER

INVESTIGATORS: James R. Gosz)
Graham A. Mark) The University of New Mexico

SUMMARY OF PROGRESS: The primary object of this study was to determine the reproductive status of *Juniperus deppeana* Steud. in Bandelier National Monument, New Mexico. Due to the apparent scarcity of seedlings and young trees, eventual local extinction seems likely.

The monument occurs at the extreme northern limit of alligator bark juniper's range, therefore, Bandelier is evidently a marginal habitat for the species. The occurrence of the species in the Jemez Mountains is rare and then usually in fairly dense but small patches. This patchy pattern indicates that the species can grow in the Jemez Mountains (and Bandelier) only if local conditions are rather special, as would be expected in a marginal habitat. Since seed is dispersed by animals, it is undoubtedly spread over many different habitat types. The species' patchy distribution in this area probably results from environmental conditions and not from failure to disperse.

Within the monument, alligator bark juniper occurs in patches of measurable density within the area enclosed by Capulin Canyon on the north, Canada-Capulin Trail to the east and south, and the monument's boundary on the west. Elevations in this area range from 6300 ft at the stream in Capulin Canyon to nearly 8000 ft on the slopes of Boundry Peak. Due to the generally west-to-east slope of the Pajarito Plateau, exposures are mostly to the east, and alligator bark juniper occurs in relatively high densities on the southern and southeastern exposures. Slopes are mostly moderate--less than 15°--although some are quite steep. Except for the organic matter content, measured soil characteristics are fairly uniform. Piñon pine, very common in the monument, is the most frequent companion tree. On the more mesic sites ponderosa pine often accompanies alligator bark juniper, and Gambel's oak, *Quercus gambelii* Nutt., is common in drier places. One-seed and Rocky Mountain juniper are also common, the former generally at lower altitudes.

Within the area of occurrence the total densities of alligator bark range from 1 to 77 individuals per 1000 m^2. Coefficients of dispersion calculated for sampling areas indicate that for densities less than 10 trees/1000 m^2 the distribution of those trees is random. Only 4 of the 11 sampling areas had densities less than 10 trees/1000 m^2. In the remaining seven sampling areas the distribution of trees was clumped.

The age structure of the population of alligator bark juniper in the monument is difficult to evaluate because of the difficulty in aging individuals through ring counts. Maximum and minimum estimates of age as determined by stem diameter differ by about 60 years. The curves of age and stem diameter indicate the growth rate of the population to be slightly decreasing with age out to a maximum of 700 years. For the population as a whole, about 50% of the individuals are less than 80 years of age. The highest proportion (nearly 15%) occurs in the 40-60 year age cohort but distribution is not uniform throughout the monument. Some areas show proportionately more individuals in younger or older age groups. This pattern would appear to be logical for a species in a marginal habitat. Slight changes in environmental conditions could affect the species' growth and reproduction to different degrees in different areas of the monument.

The mortality of the species in the monument appears highly variable from area to area. Statistical analyses showed that mortality is unrelated to site characteristics or demographic parameters. The age-specific mortality (death rate of a particular age group), although variable, suggests that mortality is highest at upper and lower extremes of age. For the majority of the population the mortality rate is age-independent and rather low (about 10%). This is supported by the low number of dead individuals in the area. The resistance of the wood to decay for this species allows one to view the accumulation of mortality for hundreds of years.

Studies on fruit production of alligator bark juniper in the monument show that this cannot be the cause of any decline in the population. During 1973 approxiamtely 1,635,000 seeds were produced in a 10,500 m^2 area. With a germination rate as low as 5%, about 81,700 seedlings should appear in the censused area. An age-independent mortality of about 10% every 20 years means that the population must generate new members at this rate if it is to maintain itself. Although reproduction may have declined over the past 50 years or more, it is still adequate overall to replace these losses. In the area censused, about 185 new trees every 20 years are required, a yearly average of less than 10. Eight seedlings of probably less than 1 year of age were seen in the study area. In some areas of the monument, where a large proportion of the population is in the youngest cohort (<20 years), the population is increasing; elsewhere it appears to be declining. However, because of the longevity of the species, it is not in immediate danger. The population could endure for decades with no reproduction at all and not seriously endanger itself, provided the overall long-term (700 years) reproduction equals the average mortality. This would no doubt lead to a patchy distribution. In fact, this pattern should be expected for a species in a marginal habitat.

Marginal habitats ought to affect a species in predictable ways. Levins' principle of allocation (Pianka 1974) provides a general theoretical framework for such predictions. By this principle, stress arising from other than optimal conditions of one environmental variable (like moisture) reduces the organism's range of tolerance along other environmental gradients (like temperature). In other words, patchy distribution is expected in marginal habitats because niche dimensions are reduced. In addition, shifts in the mean value of some environmental feature--annual precipitation, for instance--could be very slight in absolute terms (perhaps undetectable by ordinary technical methods) but could drastically alter the environment's suitability if the habitat were already marginal.

Although stepwise regression showed that none of the measured site characterictics was related to density, all sites were within a certain range of altitude, and all faced south to east. The species in this area evidently required both fairly high temperatures and fairly abundant moisture.

If either or both of these does indeed limit alligator juniper, then slight changes in one or both could account for the recent reproductive slumps. Whether local mean temperatures or precipitation have really changed is unknown. Evidence on this point is meager, but two general points are relevant.

Short-term climatic patterns in the Southwest are predictably unpredictable. Thomas (1962), studying the drought of 1942-57 in this region (California, Nevada, Arizona, Utah, Colorado, New Mexico, and Texas), pointed out that annual precipitation commonly is less than 85% of the long-term mean for fully one-third of the years of record. "Drought," which he defined as years having less than 85% of the recorded mean annual precipitation, is thus to be expected at least 1 year in 3. Native trees must of course be equipped to survive in such conditions, and *Juniperus* is so equipped. There is evidence of longer-range climatic shifts in the Southwest:

> Comparisons of growth fluctuations in recent decades with those for the past several centuries suggests that in many areas of the West the interval since 1870 or so has been one of decidedly abnormal climate. The present climatic fluctuation has taken the form of a major drought (in spots the most severe since the late 1200's) over much of the West. . .
>
> The evidence is very strong that the present fluctuation represents, in terms of centuries-long dendroclimatic data, a major change in the general circulation, at least over western North America. (Schulman 1956:69)

Whether such major and long-term climatic shifts have affected alligator bark juniper in Bandelier could not be determined, but the most recent reproductive decline dating back at least to the 1930s could reflect these changes.

The feral burro, first observed in the monument in the late 1930s (Wauer 1973), is another possible cause. No evidence was obtained in the field regarding harmful effects of burro on alligator bark juniper. Burro dung, containing large quantities of alligator bark juniper fruit and seed, was common in the fall after fruit began to drop. Such treatment aids reproduction by increasing speed of germination (Johnsen 1962) and by dispersing the seed. Livestock and deer browse juniper (Vines 1960) but no evidence of this was seen in the monument. Merkle (1952) mentions that deer sometimes stunt or kill young junipers (*J. monosperma, J. scopulorum*) by eating them but no signs of such damage were seen in Bandelier.

In summary, the population at present appears overall to be replacing its losses, although in many places current reproduction is insufficient and apparently still declining. Because of the tree's longevity, the population could survive long periods of very low reproduction, provided the losses are replaced in the future.

The most likely cause of the current reproduction slump appears to be a climate change.

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# # #

SURVEY OF AMPHIBIANS AND REPTILES IN BANDELIER NATIONAL MONUMENT

INVESTIGATOR: William G. Degenhardt
The University of New Mexico

SUMMARY OF PROGRESS: The amphibians and reptiles are for the most part not very well represented in numbers or species within the monument bounds. With the exception of certain of the lizards, these groups are not very obvious members of the park fauna.

During the summer of 1973, James Jacob, Stephen Williams, and I spent a total of 63 man-days collecting and observing in the monument. Another 12 man-days were spent in whole or in part during the summer of 1974, and Scott Berger, a student working on another project, procured a few additional records this same year.

We have, as of this date, recorded the following 12 species within the monument:

Bufo woodhousei
Hyla arenicolor
Rana catesbeiana
Sceloporus undulatus
Urosaurus ornatus
Phrynosoma douglassi
Cnemidophorus velox
C. exsanguis
Eumeces multivirgatus
Thamnophis elegans
Crotalus atrox
Pituophis melanoleucus

Another four species, not recorded from within the monument, were taken or observed immediately outside of the boundary and are probably present within. These are:

Plethodon neomexicanus
Cnemidophorus neomexicanus
Thamnophis cyrtopsis
Trionyx spiniferus

There are several species that occur in the Jemez Mountains or in the Rio Grande Valley which might very well be present in the monument. These are:

Pseudacris triseriata
Rana pipiens
Scaphiopus bombifrons
S. hammondi
Bufo punctatus
Holbrookia maculata
Phrynosoma modestum
Crotaphytus collaris
Eumeces obsoletus
Cnemidophorus tesselatus
Arizona elegans
Diadophis punctatus
Heterodon nasicus
Hypsiglena torquata
Masticophis flagellum
M. taeniatus
Opheodrys vernalis
Rhinocheilus lecontei
Salvadora grahamiae
Thamnophis cyrtopsis
T. sirtalis
Crotalus molossus
C. viridis

As of now, we have 12 species comprising the known herpetofauna and another 4 probable. The 23 species occurring in the general vicinity include some very good prospects for future addition to the monument list.

The final report, to be submitted in 1975, will include notes on distribution and habitat of all monument species recorded to that time. It should serve as a guide for monument personnel and other interested parties and should become more complete with time.

# # #

ETHNOBOTANY OF PLANTS AT BANDELIER NATIONAL MONUMENT

INVESTIGATORS: Teralene S. Foxx)
Dorothy Hoard) The University of New Mexico, Northern Branch

SUMMARY OF PROGRESS: The effort of the past 8 months was directed to studying the feasibility of developing a publication on plants of Bandelier. A prospectus of the proposed publication has been submitted. The publication will provide the visitor with an inexpensive, non-technical reference concerning the plants of the area and their ethnobotany. The text will be done by Teralene S. Foxx, the illustrations by Dorothy Hoard.

A seasonal enumeration of the plants of the headquarters area was begun in 1974. This study will be extended to the backcountry area in the next year, particularly in areas of possible ecological changes.

# # #

THE ECOLOGICAL IMPACT OF FERAL BURROS ON BANDELIER NATIONAL MONUMENT

INVESTIGATORS: David Koehler
Loren Potter

SUMMARY OF PROGRESS: In the period of June 1973 to May 1974 studies were undertaken to determine the impact of a feral burro herd upon the vegetation, soils, wildlife, and archeological sites within the Bandelier National Monument. The burro herd is not contained by natural or man-made barriers and it moves within lands of the monument, Forest Service land, University of New Mexico land, and Cochiti Indian Reservation. No clarification has been made of agency jurisdiction of the animals, therefore, there is possible conflict between policy of the New Mexico Livestock Board, the Forest Service, and the National Park Service which is charged with restoring and preserving the natural and historical environment of the monument.

Wauer estimated that when 46 burros were eliminated in 1946 they represented about one-half of the population. No further control measures have been taken and present estimates are that the herd numbers about 100-120.

A vegetational type map was developed using stereopairs of aerial photos and ground checking. This approach was combined with an analysis of forage vegetation and soils. The map denotes dominant overstory; in some cases symbolization of the shrub canopy; the dominant grass species; and the range condition and trend. Vegetation and cover were analyzed by 400-yard paced transects and the loop method. Species were divided into decreasers, increasers, and invaders. Rating vigor was based on average leaf length and number of seedstalks. Rating conditions were based on composition, vegetative cover, and vigor.

Soil condition was based on erosional susceptibility and on evidence of current erosion.

Trends of both vegetation and soils were then estimated based on observations.

Censusing of burros was done by sighting and track observations while working in the area. Usual methods of censusing large herbivores by fecal counts does not apply to burros because male burros use "defecation stations" rather than random defecation.

The vegetation was delineated into five principal types, each with three to five subtypes depending on the understory vegetation. The types, percentages of the area, and condition were as follows:

Type	% Total Area	% Condition Classes			
		Good	Fair	Poor	Very Poor
MC - Mixed Conifer	10.7	73	27	--	--
PP - Ponderosa pine	22.9	57	43	--	--
PP (PJ) - Transition type	22.1	3	63	21	13
PJ - Pinyon-juniper	18.6	--	24	64	12
JUNI - Juniper	25.7	--	--	40	60
Total Area (%)		74	10	9	7

The above summary illustrates a definite increase in the degradation of condition from the high elevation type of Mixed Conifer to the lowest elevation type of Juniper. Furthermore, the trend of condition is principally up in Mixed Conifer and becomes progressively down with decrease in elevational type. Principal grazing impact is south and west of the rim of Frijoles Canyon. The extremes are illustrated by the protection in Lower Frijoles Canyon where grass cover is profuse, desirable species predominate, and vigor is high as contrasted to the relative denudation of forage vegetation and marked erosion in Lower Alamo Canyon.

On the flats along the Rio Grande there are places where prickly pear cactus is protecting the remnant grass cover and blue grama is reduced to minimal height and vigor.

The indicators of overuse are many. Reproduction of forage species is rare and older plants are badly pedestalled. Severe soil erosion in some areas of Pinyon-juniper has even prevented invasion of overgrazing indicators and is in sharp contrast to illustrated, protected Pinyon-juniper stands which have a dense native grass cover. Desirable browse species, such as mountain-mahogany, are often severely hedged from browsing pressure. A rather unusual foraging habit of burros is represented by their ripping out the center of the rosette of sharp-spined Yucca leaves and chewing on the basal portion. The trailing habit of burros has been a factor in funneling surface erosion into resulting gully erosion. This is, of course, aggravated by the increased runoff from overgrazed areas above.

Heavy grazing by both burros and cattle has occurred on the mud flats of the Rio Grande where there were formerly good stands of saltgrass. The grass cover has been reduced and invaded by cocklebur, snakeweed, and false terragon.

The degree of soil erosion is closely correlated with decrease in vegetational cover and litter. On shallow soils, sheet erosion has left an erosion pavement; on deeper soils a crisscross pattern of gully erosion has resulted.

It is hypothesized that the limitation of winter habitat for deer is a competitive factor with the burro herd (or vice versa) and must be considered in formulating management policy which will favor native or feral populations. Cattle have no place on the monument.

Burros have produced trails across archeological sites such as Yapashi and San Miguel pueblos, have left fecal groups, and perhaps have done a small degree of breakage to walls.

The Pinyon-juniper and Juniper associations, which are preferred habitat for burros, have already seriously deteriorated in condition. Further grazing pressure, or maintenance of current levels, can only cause further unacceptable deterioration and the spread of use into other associations of secondary preference. It is estimated that utilization levels are about twice the acceptable amount. Current studies, hopefully, will provide more data on utilization.

In summary; (1) Retention of burros will result in a sacrifice by competitive displacement of native herbivores; (2) population controls after a reduction must be diligently enforced to prevent irreparable damage to the natural resource; (3) local areas of damage will occur even with a drastic reduction in numbers, short of elimination; (4) retention of the current burro herd, and of the approximately 30 trespass cattle common in 1973, is unacceptable to resource management; and (5) even complete removal of both cattle and burros will require a very long time, not years but generations, for natural recovery.

# # #

BIG BEND NATIONAL PARK

WINTER AND SPRING MOVEMENTS OF COYOTES (*CANIS LATRANS*) IN BIG BEND NATIONAL PARK

INVESTIGATORS: Douglas Stine)
James F. Scudday) Sul Ross State University

SUMMARY OF PROGRESS: There has been no significant progress since last years annual report

# # #

ECOLOGY OF CARMEN WHITETAIL DEER
BIBE-N-3A3A

INVESTIGATOR: Paul Krausman
Moscow, Idaho

SUMMARY OF PROGRESS: The project is progressing as outlined in the original proposal. Data collection is completed and is being analyzed and prepared for publication.

# # #

MOUNTAIN LION STUDY

BIBE-N-34

INVESTIGATOR: Roy McBride
Alpine, Texas

SUMMARY OF PROGRESS: A study using telemetry has been completed in the park and adjoining ranchlands. Phase two of the study, which is to transplant Mountain Lions to Santa Fe, is now under way. Completion date is May 1975. It is hoped that a helpful management technique will be developed. A total report of data collected will be turned in to the Superintendent of Big Bend National Park upon completion in May.

# # #

BEHAVIORAL ECOLOGY OF THE COLLARED PECCARY

BIBE-N-9A

INVESTIGATOR: John A. Bissonette
University of Michigan

SUMMARY OF PROGRESS: Work has proceeded as expected. The field work is complete and the thesis should be done by August 1975. Significant findings include first time documentation of group territoriality in Peccaries supported by data. A predictive formula with management implications will be generated indicating the relationships between group size, group range size, and the quality of the resource base. This will allow, among other things, an assessment of the population sizes of Peccaries in the Big Bend. A total population count will be possible with a ± 15% factor. Other findings include first time documentation of the behavior involved in breeding, plus numerous other aspects which will be in the thesis.

# # #

ANTS OF THE CHISOS MOUNTAINS, TEXAS

BIBE-N-31

INVESTIGATOR: Arnold Van Pelt
Greensboro College

SUMMARY OF PROGRESS: On 27 November 1973, a report was filed with the Superintendent which summarized the research done on this project to that time.

Since it has been impossible to arrange for travel and housing, no further work has been accomplished. The original project is about 95% complete.

With the advent of higher rainfall over serveral years, the grass areas on the margins of the Chisos are returning to good stands, and an interesting ant fauna is attracted to these stands. Work should begin in this grassland surrounding the lower woodland, and proceed into the desert. The new phase of the research should take an additional three to five summers.

# # #

MERCURY STUDY IN TERLINGUA CREEK AND RIO GRANDE AREA IN BIG BEND NATIONAL PARK

BIBE-N-I

INVESTIGATOR: James G. Houston
Sul Ross State University

SUMMARY OF PROGRESS: During the summer of 1974 samples of lizards, *Cnemidophorous tigris*, mice, fish, and millipeds were examined for mercury content. Various organs were examined. All species taken in the Terlingua Creek Area exhibited mercury.

Minnows	20-30 ppb
Lizards	0.1 to 14 ppm
Millipeds	18 ppb

The reproductive organs of the mice were particularly high. It is suggested that the study be continued with higher animals in the Big Bend Park area.

# # #

BASIC BIOLOGICAL RESEARCH ON LEPIDOPTERA OF BIG BEND NATIONAL PARK

BIBE-N-I

INVESTIGATOR: Roy O. Kendall
San Antonio, Texas

SUMMARY OF PROGRESS: No visits were made by me to the park in 1974. Instead, much time was devoted to writing several papers on the Lepidoptera. Hopefully, I will be able to resume research in the park in 1975.

Dr. & Mrs. W. W. McGuire visited the park twice during the current year. Their findings will be incorporated into my overall study. McGuire will be furnishing the National Park Service with a list of Rhopalocera taken on these two visits.

# # #

REESTABLISHMENT OF HARLEQUIN QUAIL IN BIG BEND NATIONAL PARK

BIBE-N-8

INVESTIGATOR: Roland H. Wauer
National Park Service

SUMMARY OF PROGRESS: Four birds were located in 1974; three singing males in Pine Canyon and one additional bird in upper Boot Canyon.

A report was prepared for publication in Chihuahuan Desert Symposium; final portion of the report mentions Montezuma Quail.

Plans are to examine the area again in April (if rains allow for breeding) and make one additional year's analysis of breeding success. A final report will then be prepared on the project.

# # #

FIELD STUDY AND SURVEY OF CHIROPTERA IN BIG BEND NATIONAL PARK
BIBE-N-18

INVESTIGATOR: David A. Easterla
Northwest Missouri State University

SUMMARY OF PROGRESS: During the summer of 1974, my dissertation, "Ecology of the 18 Species of Chiroptera at Big Bend National Park, Texas," was published in The Northwest Missouri State University Studies, 34 (2 and 3):165 pp. (2 parts), 1973.

My research on bats at Big Bend National Park in the future will focus primarily upon (1) recapturing banded bats and banding others, (2) continuing ecological and life-history investigations of several of the rarer species, especially the Spotted Bat.

Longevity and movement data can be obtained from banded bats only over an extended period of time. Some of my most significant data on longevity and movements will undoubtedly be obtained during future summers. Possibly this data will aid in determining why bat populations throughout the country have declined in recent years.

# # #

PETROGRAPHIC STUDY OF ALKALINE IGNEOUS ROCKS OF BIG BEND NATIONAL PARK
BIBE-N-1

INVESTIGATOR: Max Carmen
University of Houston

SUMMARY OF PROGRESS: I was out of the country, on leave from September 1973 to August 1974, but the following work was accomplished.

1. The major paper mentioned in the last report is in press (Geol. Soc. Am. Bull.) and should be out in mid-spring 1975.
2. Detailed mineralogical (X-ray and optical) studies were done on alkali feldspars from rocks of Big Bend, using advanced equipment available at the Federal Technical Institute for Kristallographie and Petrographie. These results indicate another line of research to be pursued and funds will be sought for this work from the National Science Foundation or a similar agency.

3. A picture of the crystallization history of feldspars is emerging and petrogeni models are being sought for various rock types.

# # #

LAND SNAILS OF TRANS-PECOS

INVESTIGATOR: E. P. Cheatum
Dallas Museum of Natural History

SUMMARY OF PROGRESS: No work accomplished in 1974.

# # #

Bighorn Canyon National Recreation Area

THE FISHERY OF THE BIGHORN RIVER BELOW YELLOWTAIL DAM

INVESTIGATOR: Harold R. Stevenson
Montana State University, Bozeman, Montana

SUMMARY OF PROGRESS: My thesis on the Bighorn River Fishery is in final stages of editing. The objectives given in last year's report have been accomplished.

During 1972, on weekends--holidays only, fishermen interviewed were 12.1% locals (includes Hardin), 80.0% residents (includes Billings), and 8.0% tourists (residing outside Montana). During 1973, on weekends--holidays, locals, residents, and tourists comprised 10.1, 78.6, and 11.2% of the fishermen. Changes occurred on weekdays when locals, residents, and tourists made up 14.8, 60.3, and 24.9% of the fishermen respectively. During the 1973 census, the total yield was 37,249 trout caught during 18,648 fisherman-days for an average of 2.00 fish per fisherman-day. Total yield over the study area was 30,124 pounds of trout.

# # #

BIGHORN LAKE AND BIGHORN RIVER POST-IMPOUNDMENT STUDY

INVESTIGATOR: Steve Swedberg
Montana Fish and Game Department

SUMMARY OF PROGRESS: During the period 1 March 1973 to 31 March 1974, Bighorn Lake was drawn down 20 ft in depth; however, the water level from 1 April to 1 June was allowed to increase 12 ft in depth to accommodate the walleye and perch spawning season.

Surface water temperatures on Bighorn Lake reached 73°F (22.5°C) in July. Average monthly water temperatures on the Bighorn River were warmest at Fort Smith in October

57°F; 13.9 C) and at Two Leggins Bridge in August (62°F; 16.7°C).

Gas saturation tests were conducted in April, June, July, and August on the Bighorn River below the Afterbay Dam. From 17 July through 7 August saturometer readings were taken in conjunction with three live cars containing rainbow trout. Saturometer readings varied between 112.6% and 123.5% saturation. On 7 August 1 trout out of 37 exhibited a gas bubble on its opercle. ,

Creel census on Bighorn Lake showed a catch rate of 0.3 fish per hour. Walleye was the most abundant game fish taken and made up 33% of the catch. Montana residents made up 56% of the fishermen and took 72% of the fish. About 77% of the fishing was done in the Montana portion of the reservoir.

Analysis of the catch from 52 gill net sets showed that they took 524 fish. Together, carp and suckers made up about 38% of the catch and walleye made up about 39%.

Age determinations were made from walleye scales taken from creel census and gillnetting in 1972. Age class IV was the dominant age class and made up 58% of the 307-fish sample. Peak annulus formation for walleye occurred about mid-May.

The stomachs of 58 rainbow trout collected from the Bighorn River were analyzed. Ephemeroptera and diptera were the most important insects eaten.

A major problem on the Afterbay Reservoir has been fluctuating water levels--resulting in an out-migration of planted trout down river.

Lately, major problems on the Bighorn River have been Crow tribal claims on the water and access. Future problems will undoubtedly arise out of the sale of water from the Bighorn River for industrial and irrigation purposes. Electrofishing success has been poor.

Previous findings. Investigations on Bighorn Lake have indicated:

1. That from 1 April through 1 June 1971 and 1972, drawdowns were 25 and 30 ft, respectively. The lowering of the lake level during this period corresponds to the walleye and perch spawning period of mid-April through mid-June.

2. That a critical period for lake trout occurs annually during September.

3. That to increase the survival of planted fish, plants should not be made from one location and near the shoreline.

OBJECTIVES: 1. Obtain knowledge of major game fish with regard to distribution, food habits, growth and spawning.

2. Obtain data on water temperatures and dissolved oxygen levels in Bighorn Lake and water temperature data from the Bighorn River.

3. Collect creel data from Bighorn Lake, Afterbay Reservoir, and the Bighorn River below the Afterbay Dam.

PROCEDURES: *Physical Measurements*. Surface elevation and acreage data for Bighorn Lake were supplied by the U. S. Bureau of Reclamation and figures for the first day of each month were graphed in Fig. 1. Water temperatures were taken at eight stations and dissolved oxygens were taken at four stations. These stations are located on Fig. 2 as stations A through H. Stations A and H were used in this report for comparative purposes. Station A provides data at a distance of 1 mile from the dam and station H is 41 miles from the dam. Temperature profiles were recorded at least once a month in April through July and from September through November 1973. At some stations, temperatures were not taken in July and August because the temperature probe was lost. Temperatures were taken at 10-ft depth intervals using a FT-3 Marine hydrographic thermistor thermometer. Temperatures were recorded to at least 200 ft in depth in deep water and to the bottom in waters less than 200 ft. A Kemmerer sampler was used to collect water samples and each dissolved oxygen sample was fixed at the time of collection with Hach powder pillows and titrated at a later date. Dissolved oxygen samples were taken at stations A, D, F, and H in September, October, and November. Water temperatures were taken on the Bighorn River at Fort Smith and Two Leggins Bridge and are on file at Fort Smith, Montana. Taylor 30-day thermographs were used to record continuous temperature records in degrees Fahrenheit. A Weiss saturometer was used to take the saturation of gases in the waters of the Bighorn River. Tests were participated in by the U. S. Bureau of Reclamation and the Montana Department of Fish and Game.

Creel Census A. Census on Bighorn Lake was conducted by personnel from the Wyoming Game and Fish Commission at Horseshoe Bend, Wyoming, and by the Montana Department of Fish and Game at Ok-A-Beh Landing, Montana. Census was usually taken on the first weekend of each month and on major holidays, in May through September (11 days of census). Other censuses were taken on boat patrol and when the opportunity arose, from April through September (29 days).

Creel Census B. Taken in Montana on the Afterbay Reservoir and on the Bighorn River below the Afterbay Dam downstream about 39 miles to the Bighorn River Bridge. The census was taken by Harold R. Stevenson, master of science degree candidate at Montana State University. The data will be available upon completion of Stevenson's thesis.

Creel census consisted of asking a fisherman his place of residence, areas fished, and checking the number of each species caught. Biologists usually took lengths and weights of individual fish.

The food habit portion of this report includes fish taken during creel census on the Bighorn River from 1967 through 1972. Fish were collected in various months and all but five fish were collected within 1 mile of the Afterbay Dam. Each fish was examined for food in the esophagus and stomach. Contents were processed numerically, volumetrically, and by the frequency of occurrence method.

Fish population survey. Gill nets were used in Bighorn Lake to collect fish for analyses of species composition, length-weight relationships, age and growth, spawning condition, and food habits. Stomach samples from trout and walleye were collected and preserved for future analysis. Nets were 125 ft x 6 ft graduated mesh sampling gill nets with nylon webbing, mesh sizes ranged from 3/4-inch to 2-inch-square mesh. Seven areas were netted with a total of 36 bottom sets and 16 floating sets being set. All nets were set overnight except three nets which were set for 24 hours due to high wind. Nets were set in April through June and September through December. Fish scales were aged with a Spencer binocular microscope. Fish were weighed to the nearest 0.01 pound and their total length measured to 0.1 inch.

FINDINGS: Physical measurements. Maximum drawdown on Bighorn Lake was 20 ft during the period of March 1973 to March 1974. The lowest water level occurred March 13 at an elevation of 3618 and the highest level occurred 15 August at an elevation of 3638. Spring runoff usually occurs from late May to early July and the reservoir operations bring the water level down in winter and spring to accommodate water from runoff. At the request of our Department the water level was not dropped by the U. S. Bureau of Reclamation during the period from 1 April through 1 June. It was felt that most of the walleye and perch spawning and egg incubation would be completed within this period. Subsequent drawdown after 1 June would probably be slow enough to allow for additional recruitment. The water level increased 12 ft from 1 April through 1 June and continued to slowly rise in June.

Yellowtail Dam is 525 ft in height. It was completed in October 1965 and filled for the first time in June 1967. The top of flood-control storage is at an elevation of 3657. At this level the surface acreage is 17,298. Usual water discharge is through four power penstocks located at elevation 3450. The dam was designed for power, flood control, recreation, and irrigation; the latter use has not been utilized, except for an irrigation diversion in the Afterbay Dam. About 42 miles of the reservoir is in Montana and about 25 miles is in Wyoming. About two-thirds of the reservoir is situated in a narrow canyon characterized by a precipitous shoreline of solid rock and rubble walls.

Water temperatures at stations A and H are given in Figs. 3, 4, and 5. A thermocline was present at station A on 22 October at approximately 220 ft in depth. No thermoclines were recorded at station H. Surface waters reached a high of 73°F (22.5°C) in July at station A.

The lowest dissolved oxygen reading was 2.2 ppm and was obtained at station F on 6 September at approximately 160 ft in depth (bottom) and at a temperature of 63°F (17.5°C). By 24 September the dissolved oxygen reading at 160 ft in depth at station F was 6.6 ppm and the water temperature was about 58°F (14.7°C).

At Fort Smith water temperatures in the Bighorn River were warmest during October and averaged 57°F (13.9°C). Water temperatures in 1971 and 1972 averaged 63 and 62°F (17.2 and 16.7°C, respectively), and occurred in August in both years. Latent warming of the river in 1973 could have been a result of cool-water retention in Bighorn Lake during the late spring, plus retentivity of a high lake level throughout the summer.

At Two Leggins water temperatures were warmest during August and averaged 62°F (16.7°C). In both 1971 and 1972 the warmest water occurred in August, but averaged 69 and 67°F (20.6 and 19.4°C, respectively).

In early April 1973 Stevenson found several dead rainbow trout on a small island located one-half mile below the Afterbay Dam on the Bighorn River. The trout had bubbles on their opercles and in some of their fins. Saturometer tests for the presence of gas saturation in the water were begun on 12 April using a Weiss saturometer. Tests were conducted at various locations between the Bighorn River Bridge and the Ok-A-Beh boat ramp on Bighorn Lake.

The lowest reading was taken near the Afterbay Reservoir Bridge and was 99.6% saturation. The highest reading was 116.4% and was obtained 300 ft below the Afterbay Dam (with only the sluiceway gate open). The discharge rate during the tests was about 2969 cfs. Other tests varied the total discharge rate (about 6000 cfs) by manipulating the sluiceway and radial gates. Saturation readings ranged between 106.2% and 120.6% saturation.

A study was begun on 17 July and ended 7 August. Saturometer readings were taken daily at three stations on the Bighorn River. A live-car was installed at each station and each car contained 13 catchable-sized rainbow trout. The first car was placed near the shoreline and about 300 ft below the Afterbay Dam. The second car was placed near the shoreline and about one-third mile below the Afterbay Dam. The third car was installed near the shoreline and at a distance of 1 mile below the Afterbay Dam. The trout were fed from 21 July through 6 August. During the study period water temperatures ranged between 52°F (11.1°C) and 56°F (13.3°C), water discharges ranged between 1107 and 1629 cfs and saturometer readings varied between 112.6% and 123.5% saturation. Two trout, one each from different cars, succumbed during the test period and their deaths were not attributed to gas embolism. On 7 August Charlie E. Smith, hatchery biologist with the U. S. Fish and Wildlife Service, Fish Cultural Development Center, Bozeman, Montana, checked 37 trout for signs of gas embolism. Only one trout exhibited a gas bubble on its opercle. A few trout had very small bubbles in their mouths.

Creel Census A. In 1973 a total of 1159 fishermen caught 1255 fish in 4596.5 hours. The catch rate was 1.1 fish per man and 0.3 fish per hour. Montana residents made up about 56% of the fishermen and took about 72% of the fish. About 77% of the fishermen fished in Montana and 23% in Wyoming. Catch by number and percent of total catch (in parentheses) were yellow perch - 526 (42); walleye - 418 (33); black crappie - 185 (15); brown trout - 55 (5); rainbow trout - 42 (3); burbot - 16 (1); green sunfish - 3; channel catfish - 3; black bullhead - 3; cutthroat trout - 1; brook trout - 1; and sauger - 1 (all less than 1%). The average length of 86 walleye was 18.7 inches and the average weight was 2.16 pounds.

Fish population survey. A total of 52 gill net sets took 524 fish (Table 1). A total of 36 bottom sets took 5.8 game fish per net (walleye, sauger, kokanee salmon, whitefish, brown and rainbow trout) and 4.2 carp and suckers per net. A total of 16 floating sets took 2.9 game fish per net (walleye, brown and rainbow trout) and 3.1 carp and suckers per net.

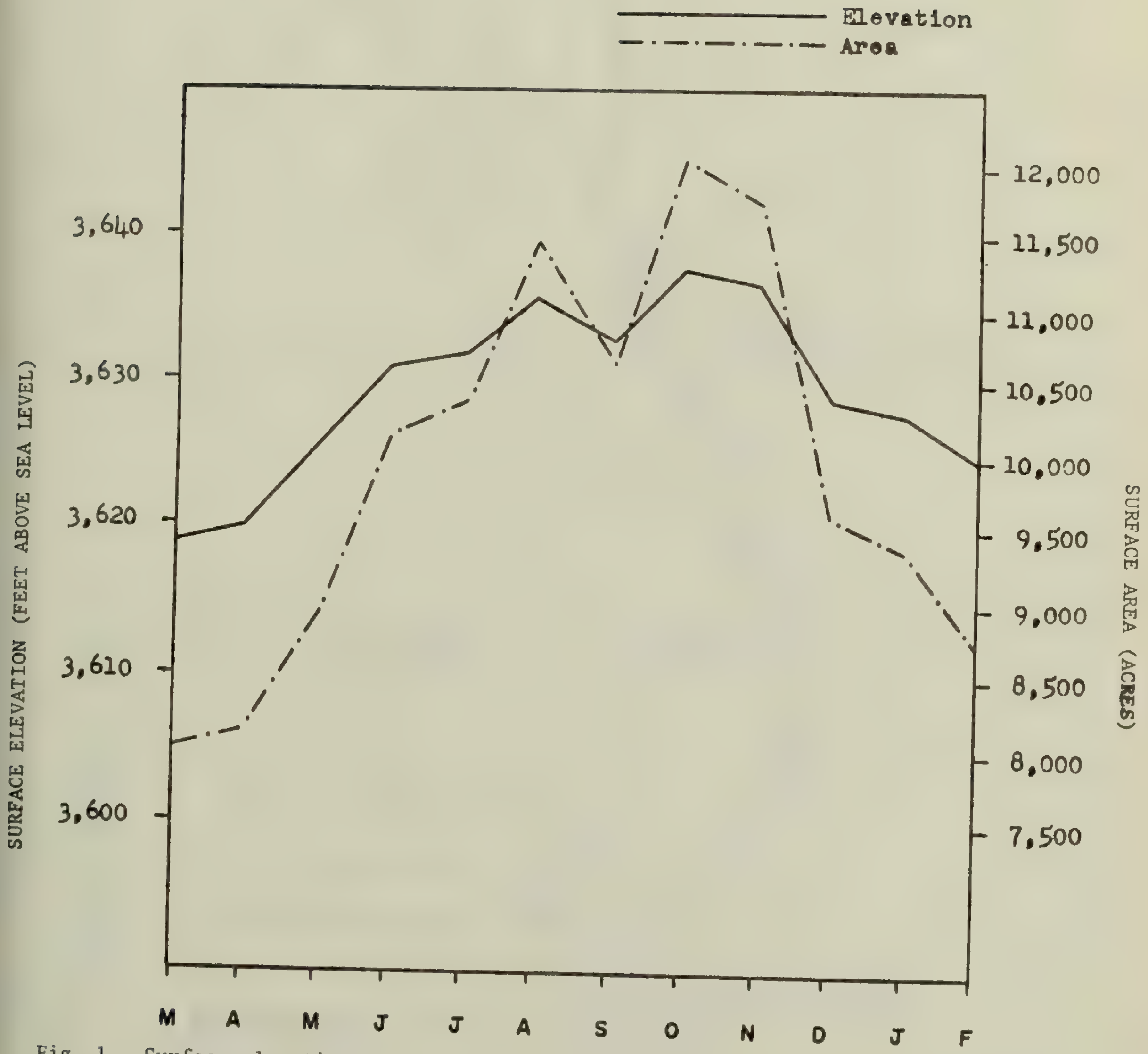


Fig. 1. Surface elevation and area--Bighorn Lake, March 1973 through February 1974.

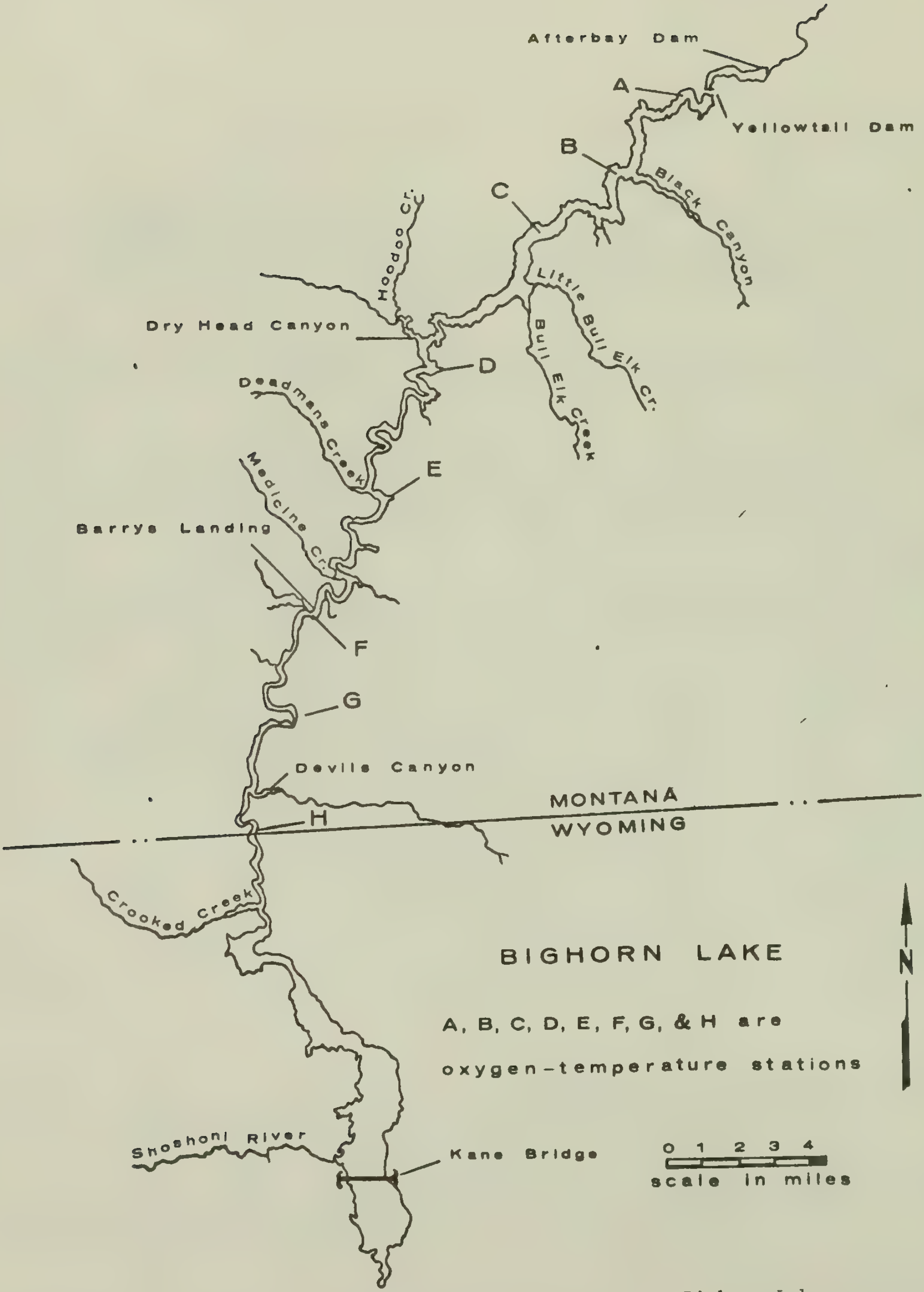
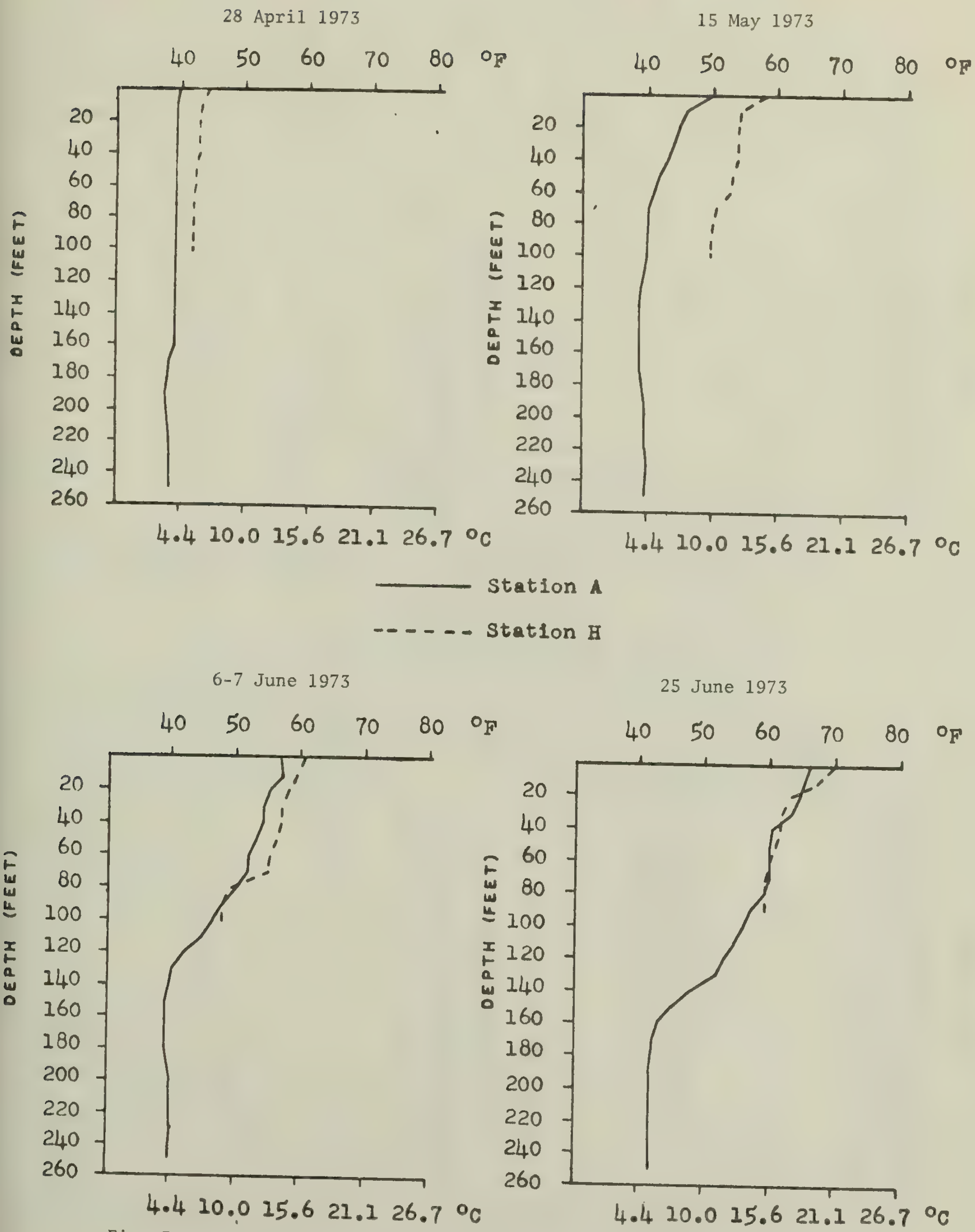


Fig. 2. Oxygen-temperature stations on Bighorn Lake.


28 April 1973

15 May 1973

6-7 June 1973

25 June 1973

Fig. 3. Water temperatures in Bighorn Lake at stations A and H, 1973.

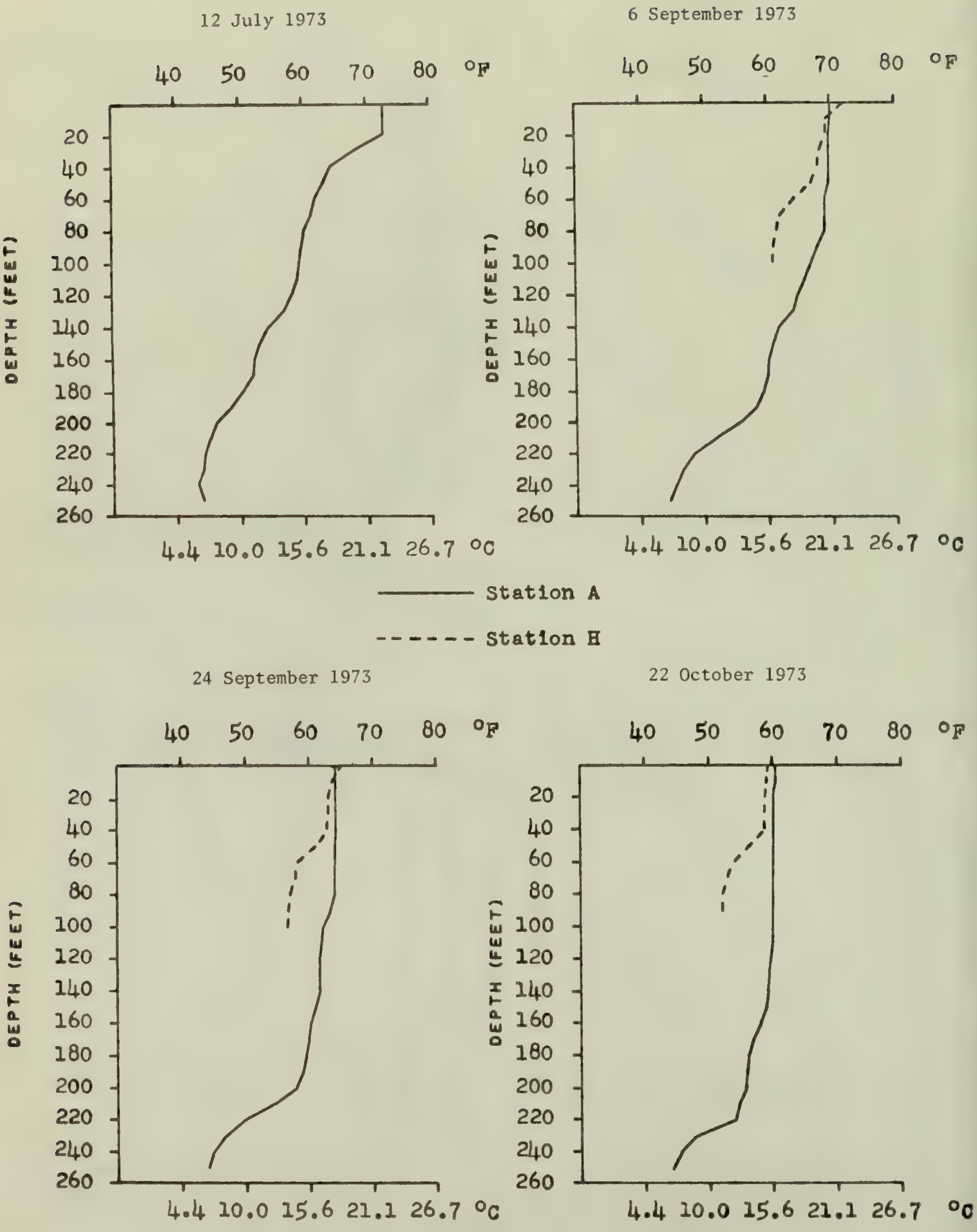


Fig. 4. Water temperatures in Bighorn Lake at stations A and H, 1973.

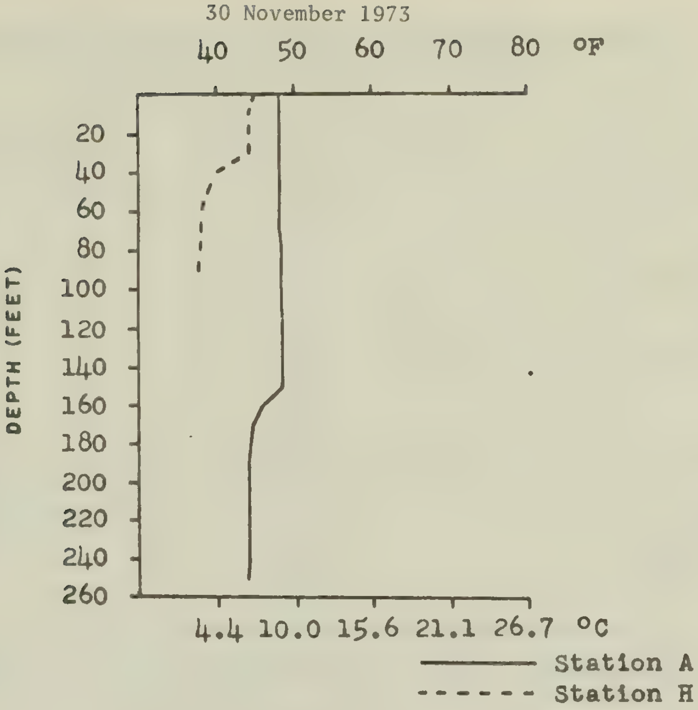


Fig. 5. Water temperatures in Bighorn Lake at stations A and H, 1973.

Table 1. SPECIES COMPOSITION AND RANGE IN LENGTH AND WEIGHT OF FISH GILLNETTED IN BIGHORN LAKE, 1973

Species	Number	Percent	Range	
			Length	Weight
Walleye	203	38.7	6.8-26.9	.09-7.47
White sucker	101	19.3	7.0-17.1	.10-2.21
Longnose sucker	47	9.0	9.3-16.4	.30-1.72
Yellow perch	42	8.0	5.2-11.6	.06-0.68
Brown trout	41	7.8	12.0-22.4	.60-3.50
Shorthead redhorse	27	5.1	6.3-17.5	.07-2.20
Carp	26	5.0	13.0-19.8	1.13-4.95
Burbot	22	4.2	20.7-27.5	1.65-4.73
Rainbow trout	6	1.1	11.5-17.9	.47-2.00
Sauger	2	0.4	10.7-11.4	.29-0.37
Stonecat	2	0.4	8.2-10.2	.22-0.37
Black crappie	2	0.4	4.4	.04
Channel catfish	1	0.2	16.6	1.47
Mountain whitefish	1	0.2	14.5	.97
Kokanee	1	0.2	11.1	.37
Total fish	524			

Table 2. THE AVERAGE NUMBER AND AVERAGE TOTAL WEIGHT OF FISH PER GILL NET, BIGHORN LAKE, 1973

Species	Average number/net	Average total weight/net
Walleye	3.90	7.83
White sucker	1.94	2.70
Longnose sucker	0.90	0.94
Yellow perch	0.81	0.16
Brown trout	0.79	1.59
Shorthead redhorse	0.52	0.43
Carp	0.50	1.25
Burbot	0.42	1.17
Rainbow trout	0.12	0.18
Sauger	0.04	0.01
Stonecat	0.04	0.01
Black crappie	0.04	(less than 0.01)
Channel catfish	0.02	0.03
Mountain whitefish	0.02	0.02
Kokanee	0.02	0.01

Table 3. CALCULATED AGE AND MATURITY OF WALLEYE TAKEN FROM BIGHORN LAKE IN 1972 BY GILLNETTING AND ANGLING

Age Class	Immature	Male	Female	Unknown	Percent Composition
0	1	--	--	--	0.3
I	11	4	3	--	5.9
II	23	6	6	8	14.0
III	3	18	5	8	11.1
IV	1	80	68	29	58.0
V	--	9	14	9	10.4
VI	--	--	1	--	0.3
Total fish	39	117	97	54	100.0

Table 4. AVERAGE LENGTH, WEIGHT AND RANGE OF WALLEYE BY AGE CLASS, BIGHORN LAKE, 1972[1]

Age Class	Number	Average total length	Range in length	Average weight	Range in weight
0	1	7.1	7.1	.10	.10
I	14	13.2	7.7-15.3	.82	.13-1.24
II	41	14.6	12.5-17.0	.98	.60-1.72
III	25	17.5	15.7-19.0	1.71	1.30-2.03
IV	84	19.8	17.8-22.9	2.57	1.69-4.38
V	22	21.5	19.4-24.5	3.36	2.20-4.88
VI	1	24.4	24.4	5.18	5.18

[1] Does not include fish that were ripe or fish estimated to have recently spawned.

Table 5. FOOD OF 58 RAINBOW TROUT FROM THE BIGHORN RIVER

	Contents of esophagus and stomach	Number	Percent of food	
			Volume	Frequency of occurrence
Aquatic	Algae	-	45.0	21.1
	Zooplankton	-	0.2	4.5
	Fish	1	0.1	0.4
	Pulmonata	24	0.3	1.6
	Amphipoda	34	0.6	3.3
	Gordiacea	1	Less than 0.1	0.4
	Ephemeroptera	10,728	35.2	16.7
	Plecoptera	100	0.1	4.5
	Hemiptera	7	0.1	1.2
	Coleoptera	1	Less than 0.1	0.4
	Trichoptera	153	1.2	4.9
	Diptera	8,744	9.4	22.8
Terrestrial	Oligochaeta	9	0.1	0.4
	Orthoptera	2	0.2	0.4
	Hemiptera	3	Less than 0.1	0.8
	Homoptera	38	Less than 0.1	0.8
	Coleoptera	4	Less than 0.1	0.8
	Hymenoptera	13	Less than 0.1	2.4
	Unidentified	4	Less than 0.1	0.4
	Detritus	-	7.5	12.2

Bottom sets averaged 13.1 hours per set and floating sets averaged 19.3 hours per set. Gill nets took 15 species of fish with carp and suckers making up about 38% of the catch. Walleye made up about 39% of the catch. Walleye averaged 3.90 per net (Table 2) and weighed an average of 7.83 pounds per net (based on all types of sets). A total of 198 walleye averaged 17.5 inches and 2.01 pounds, 31 brown trout averaged 18.4 inches and 2.01 pounds, and 1 kokanee salmon was 11.1 inches and 0.37 pounds.

Age and growth. Age estimates and maturity of 307 walleye collected from Bighorn Lake in 1972 by gill net and angling are given in Table 3. Age class IV was the dominant age class and represented 58% of the sample. Most male and female walleye were mature in their third year of life. Conclusions about annulus formation were: (1) a few fish had formed an annulus by 28 and 29 April except those fish collected from the Devils Canyon area where 36 of 41 fish had already formed their annulus by 30 April, (2) peak annulus formation for walleye in 1972 occurred about mid-May, and (3) most of the walleye had formed their annulus by late June.

Table 4 furnishes the average length, weight, and range of walleye by age class. Overlap in length and weight ranges occurred between age classes because some fish were taken just prior to annulus formation, because of genetic differences, or because of sexual differentiation. The importance of sexual differentiation in regard to the age-length-weight overlap can be demonstrated by walleye of age class IV, where 30 males averaged 19.3 inches and 2.45 pounds and 25 females averaged 20.1 inches and 2.75 pounds.

Creel Census B. The food habits of 58 rainbow trout collected from the Bighorn River are given in Table 5. Ephemeroptera (Mayflies) and Diptera (primarily midges) were the most important insects eaten by rainbow trout. Mayflies were eaten most frequently in late July through early September. Midges were ingested throughout the year, but were taken most frequently in late winter and early spring. Few midges were found in the trout when their diet consisted mainly of Mayflies. Algae made up 45% (by volume) of the food items eaten; however, it was felt that the intake of algae was related to the presence of aquatic insects, snails and amphipods in the algae. Prior to the collections made in 1972, none of the diets contained freshwater shrimp. Out of 11 fish collected in January and March 1972, 8 fish had freshwater shrimp in their diets.

RECOMMENDATIONS: 1. Continue to monitor the growth and reproduction of walleye in Bighorn Lake. Water-level stabilization or an increase in the water level in April through June is important for successful walleye and perch reproduction.

2. Continue checking on the success of kokanee salmon plants in Bighorn Lake. Kokanee salmon growth and the success of plants in 1971 through 1975 are important to providing a fishery for the trout fishermen and future spawners for natural propagation.

3. I would recommend an inventory of the species of fish inhabiting the middle and lower reaches of the Bighorn River. This is important due to recent proposals for water use by industry.

Waters referred to:

22-9835-05
22-9834-05
22-0490-02
22-0495-01

Tentative plans are aimed at reducing some of the creel census and gillnetting activities in June, July, and August.

Budgetary limitations and future plans for diverting water from the Bighorn River for industrial purposes are reasons for a reduction in effort. More of the investigator's time must be spent on the Bighorn River below the town of Hardin (site of proposed water diversion).

# # #

BISCAYNE NATIONAL MONUMENT

SMALL MAMMAL AND VEGETATION STUDIES ON TOTTEN KEY

BISC-N-15

INVESTIGATOR: Charles E. Hilsenbeck
University of Miami

SUMMARY OF PROGRESS: All literature and preliminary sampling work has been completed, and the actual vegetation map and evaluation of sampling techniques is underway.

There is a small number of cotton mice extant on the key. However, there are too few to estimate using conventional census techniques.

Several very large *Lignum vitae* trees are on the southern end of the island. It appears that they are the largest specimens of this species in existence in the continental United States.

The island provides habitat for three rare birds: the Mangrove Cuckoo, the Black-whiskered Vireo, and the White-crowned pigeon.

Work will proceed in December 1974 as approved by the M.S. Committee.

# # #

THERMAL TOLERANCE OF THE SEAGRASS *THALASSIA TESTUDINUM*

BISC-N-21

INVESTIGATORS: Anitra Thorhaug) University of Miami
Raymond F. Hixon)

CONCLUSIONS: The short-term (48 hr) temperature tolerances of *Thalassia* observed in the laboratory are markedly higher than those for long-term exposure (more than 6 days*) found in the field.

The combined effect of high temperature and high salinity reduces the upper lethal temperature limit of *Thalassia* more than either factor individually.

The upper lethal temperature limits of *Thalassia* are time and salinity dependent. At each salinity tested, increased exposure time reduced the upper lethal thermal limit for short time periods. The absolute temperature of upper thermal tolerance was salinity dependent.

Equilibrium temperatures, defined as the temperature at which further increases in the period no longer reduce survival at a particular temperature, were not obtained in this study.

The upper lethal thermal limits for *Thalassia* found in this study are: 37°C at 12 hr exposure to 20 ; 36°C at 12 hr exposure to 36 , at 12 hr exposure to 50 , at 24 hr exposure to 20 , and at 24 hr exposure to 36 ; 35°C at 48 hr exposure to 20 and at 48 hr exposure to 36 ; 34°C at 24 hr exposure to 50 ; and 33°C at 48 hr exposure to 50

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*6 days is an intuitive rather than experimentally determined time period.

# # #

BUTTERFLY SURVEYS, BISCAYNE NATIONAL MONUMENT
BISC-N-16

INVESTIGATOR: Charles V. Covell, Jr.
University of Louisville

SUMMARY OF PROGRESS: On the morning of 14 May 1974, a trip was made to Old Rhodes Key. We entered the island from the south side, and followed a trail cut through the hardwood hammock. We spent approximately 2 hr there. Inside the hammock, only one butterfly species was abundant: this was the Florida Purple Wing (*Eunica tatila tatilista*). Some of this species was seen out over the water, flying from one key to another. Several specimens (11) were collected.

Several hundred yards into the hammock, the first specimen of the Schaus Swallowtail, (*Papilo aristodemus ponceanus*) was seen and captured. It was a battered male, attesting that it had been on the wing for several days or longer. Two more were taken later, both damaged males. About four others (including at least one female) were seen but not captured.

Other species of butterflies seen in the hammock were species common on the mainland and through the keys:

Dryas julia
Heliconius charitonius
Phoebis agarithe
Appias drusilla
Polygonus leo (or *manueli*)

Also seen was the beautiful day-flying Peridopid moth (*Composia fidelissima*) which is pictured on the cover of Kimball's *Lepidoptera of Florida*.

Later during the day on Elliott Key, I saw two *Papilo aristodemus ponceanus* males, and took one in good condition. Other butterfly species recorded were: *Battus polydamas, Phyciodes frisia, Phyciodes phaon, Dryas julia, Nathalis iole, Appias drusilla, Phoebis agarithe, Leptotes cassius theonus, Hemiargus ammon bethunebakeri, Epargyreus zestos,* and *Atalopede campestris*. No *P. andraemon bonhotei* were sighted on either key. *Atalopede campestris* is the only new addition to lists published by L. Brown and Covell.

Butterfly numbers were down from the same time 2 years ago, and slightly so from the same time in 1973. Drought appears to be the reason for this situation. I feel the population of *Papilo aristodemus ponceanus* is still flourishing on Old Rhodes and Elliott keys. I did not get a chance to sample Totten Key due to the short time in the park and the great amount of that time spent on the water.

# # #

ECOLOGICAL STUDY OF OLD RHODES LAGOON
BISC-N-0008

INVESTIGATOR: Robert F. Holm
Northwestern University

SUMMARY OF PROGRESS: The second field period was completed on 1 August 1974 (two periods in the field 25 March-28 March 1974 and 26 July-1 August 1974). Sorting of all epibenthic samples has been completed. I am now in the process of ashing benthic phanerograms and algae. Invertebrates are being sorted to at least family, and counted. Fish transect data has been compiled. Sediment samples are being dried and sieved. Weather data from Homestead Air Force Base for the year 1973-74 has been received.

I am starting to write the materials and methods sections of my dissertation. Plankton data (phyto and zoo) have been compiled. Stomach analyses of fish caught in the lagoon have been carried out. I expect to finish dissertation by May 1975 and receive Ph.D. degree in June 1975.

# # #

WATER QUALITY STUDIES, BISCAYNE BAY
BISC-N-06

INVESTIGATORS: Purkerson)
Blanchard) National Park Service
Tilmant)

SUMMARY OF PROGRESS: The monitoring of the quality of monument waters was expanded beyond the immediate vicinity of Turkey Point to include representative sampling of all portions of the bay. In addition, eight stations were established in Old Rhodes Lagoon. This lagoon is a very shallow, fragile, and unique benthic community which should be included in the monitoring program. Attempts were made to maintain the minimum monthly sampling schedule of standard physical parameters although some months were missed during periods when investigators were not available.

FINDINGS TO DATE: Salinity levels at those stations monitored within the bay averaged 1.9 0/00 higher than 1973 readings during the first quarter of this year. During the second quarter, salinities averaged 0.6 0/00 lower than 1973 readings but were 3.4 0/00 higher than 1972 second quarter readings. No readings were obtained during the third quarter. Only 1972 data is available for fourth quarter comparisons and salinities averaged 1.5 0/00 lower than 1972 readings. The number of observations and amount of data to date are not sufficient to draw conclusions from these results. However, it appears greater fluctuations in salinity may be occurring. Overall average turbidity did not differ significantly from measurements of previous years. Temperatures fluctuated from a maximum of 28.3°C (83°F) on 5 May near Black Point to 16.5°C (62 F) on 10 December near West Arsenicker Key. Overall average water temperature was 23.3°C (74°F).

PLANS FOR 1975: Close monitoring of water quality, in an attempt to gain a better understanding of natural fluctuations of these parameters and detect long-term changes, will continue. Sampling frequency and number of stations will depend on funding and personnel available.

# # #

HUMAN IMPACTS ON THE CORAL REEF ECOSYSTEM
BISC-N-03

INVESTIGATORS: Gary E. Davis)
Jim Tilmant) National Park Service

OBJECTIVES: To quantify dynamic biological processes in the coral reef ecosystem that relate to human activity, especially those effects of man-caused turbidity, anchor damage, and physical disturbances.

METHODS: Patch reefs representing varying reef communities will be selected for study. Mooring buoys will be provided at these reefs as alternatives to anchoring. Close monitoring of all physical parameters, coral growth, and numbers of fish will be maintained and compared to similar reefs selected as controls. Numbers of visitors using the reefs will be closely monitored.

RESULTS: Preliminary surveys and tentative selection of reefs have been made. Six photopoints have been established on one of these reefs. The process of training personnel in fish census techniques has begun. Work is in progress on obtaining mooring buoys and constructing buoy anchor blocks.

PLANS FOR 1975: Mooring buoys will be placed at selected reefs. Visitor information handouts will be written describing unique and interesting features at each reef. Close monitoring of visitor use of these reefs will be conducted. Environmental monitoring on a monthly schedule will continue. Baseline data on fish populations, coral growth, and photopoints will be repeated quarterly.

# # #

RADIOLOGICAL SURVEILLANCE OF FP&L NUCLEAR POWER PLANT
BISC-N-09

INVESTIGATORS: J. C. Eakins)
James Dolthat) Florida Department of Health and Rehabilitative Services

SUMMARY OF PROGRESS: Periodic sampling on a weekly, monthly, and quarterly basis continued at eight stations within Biscayne National Monument. Radiation readings were taken from the following mediums:

Estuarine water
Estuarine bottom sediments
Crustacea (blue crab)
Fish, Carnivore
Fish, Herbivore
Sea grass (manatee grass)
Sponges
Mangrove leaves

Quarterly reports covering the period from 1 January 1973 through 30 June 1974 have been received. These reports give types of samples, date of collection, sample location, and results of analysis performed.

# # #

GROWTH RATES OF GORGONIAN CORALS
BISC-N-I

INVESTIGATOR: Frederick M. Bayer
University of Miami

SUMMARY OF PROGRESS: Tissue samples have been collected monthly from tagged colonies of *Plexaura homomalla* to determine histological characteristics of males and females, sex ratio, breeding season, and site of fertilization and early development. It was found that male colonies are recognizable only during June, July, and August but not in other months, because spermaries are completely resorbed after breeding season. No histological difference between inactive males and immature females has been found so far. No histological evidence has been found regarding time or place of fertilization nor place where cleavage and early development of the planula larva takes place. Histological data regarding the cycle of development and utilization of zooxanthellae in *Plexaura* tissues have been assembled but are still inadequate for meaningful interpretation. Lack of funding has precluded thorough investigation of this aspect of *Plexaura* biology. Preliminary histological description of *P. homomalla* has been published in S.T.O. no. 12. Studies of growth and repopulation of *Plexaura*, based upon data collected prior to this project and before establishment of the monument, also have been published in the same volume.

Because of the unusual biological and biomedical significance of *P. homomalla*, studies directed toward these basic topics merit continuation and, indeed, intensification. Whether this will be possible depends chiefly upon the funding that may be obtained.

# # #

TERRESTRIAL VEGETATION STUDIES
BISC-N-01

INVESTIGATOR: Jim Tilmant
National Park Service

OBJECTIVES: The objectives of this research project as outlined in the study proposal are:

1. Preparation of a vegetative map showing the major vegetative communities of all land areas.
2. Determine species composition and age of mature hardwood hammock.
3. To quantify and qualify the recovery of woody shrubs and trees into bulldozed or burned areas in or adjacent to the 1968 road clearing along the center of Elliott Key.

SUMMARY OF PROGRESS: The first of these objectives has been completed and maps were turned over to the park master-planning team in 1971. Since that time, no additional vegetative work has been done due to lack of personnel and funds. We may be able to resume some limited amount of work on this project during the coming year.

# # #

RECOVERY OF MARINE PLANTS IN AREAS OF THERMAL DISCHARGE

INVESTIGATOR: Steven Bach
University of Miami

SUMMARY OF PROGRESS: Most of the work will be completed by January 1975 but the portion I am doing for my doctorate on the production of calcareous macro-algae will continue until July or August 1975.

Annual report for 1974 already has been submitted to the National Park Service by Raymond Hixon.

Papers are in progress describing and summarizing the results for the last 5 years at Turkey Point and Last 3 years in Card Sound.

# # #

BLUE RIDGE PARKWAY

POPULATION DYNAMICS OF *PITYMYS PINETORUM*

INVESTIGATOR:	J. Scott Ziesenis North Carolina State Univeristy
SUMMARY OF PROGRESS:	Pine mice have not been located on the parkway as initially hoped. Small trap lines have yielded several species.

# # #

OBSERVATIONS ON COLLECTIONS OF LOWER FORMS

INVESTIGATOR: Charles Morlang, Jr.
Hollins College

SUMMARY OF PROGRESS: I observed the fern flora in Rockcastle Gorge this year. No collections were made until the summer when Ranger Stewart Johnson and I made a field trip into the gorge. We collected a frond of each specimen found that day so that he and other rangers could study them.

# # #

INVESTIGATION OF WINTER STONEFLY FAUNA IN THE BLUE RIDGE MOUNTAINS OF NORTH CAROLINA

INVESTIGATOR: Virginia R. Tolbert
University of Tennessee, Knoxville

SUMMARY OF PROGRESS: Little field work has been done so far as I am mainly interested in the winter Plecopteran fauna. At present my emphasis is on background information concerning what species should be present and under what environmental conditions in order to be able to predict what species should be found and what ranges of conditions for this area.

I am also interested in determining what species are actually present since little work has been done on the Plecopteran fauna of the Appalachian region.

Field work was carried out in the last few weeks of December; laboratory identification of specimens found is taking place at the present.

# # #

A BIOSYSTEMATICS STUDY OF THE EASTERN SPECIES OF *HEUCHERA* (SAXIFRAGACEAE)

INVESTIGATOR: Elizabeth Fortson Wells
University of North Carolina

SUMMARY OF PROGRESS: The breeding system has been investigated in seven species of *Heuchera*. Almost all combinations are completely fertile, except when *H. villosa* is the pollen parent. Flower ontogeny, inflorescence branching patterns, leaf anatomy, and chemical components are being investigated to elucidate the relationships among the species. Comparisons are also being made with species from New Mexico, California, Colorado, and Oregon to understand the normal range of variation within the genus. The genus *Heuchera* is also being compared to certain other closely related genera with respect to leaf anatomy, inflorescence origin and branching pattern, and chemical components.

The anatomical work has progressed very well. The chemical studies are to begin this winter. The artificial hybrids are just beginning to germinate. With luck, the whole project will be completed within 1.5 year. I plan to collect flowers, leaves, and whole inflorescences next spring as my last collection on this work.

# # #

FUSIFORM RUST TESTING CENTER

INVESTIGATOR: Robert D. Wolfe
U. S. Forest Service

SUMMARY OF PROGRESS: An operational testing center for resistance testing of pine trees to the rust disease *Cronartium fusiforme* has been established.

Certain clones show more resistance to *C. fusiforme* than others.

The testing center will be expanded to cover other pine tree diseases.

# # #

BIOSYSTEMATICS OF THE BLOOM FORMS OF *RHODODENDRON CALENDULACEUM* (MICHX.) TORREY

INVESTIGATOR: Frank F. Willingham, Jr.
Callaway Gardens

SUMMARY OF PROGRESS: This project is complete. The results were submitted for publication in July 1974 and are awaiting final editing.

The National Park Service will be acknowledged in the publication and a reprint sent as soon as one is available.

# # #

USEFUL PLANTS OF THE BLUE RIDGE FROM SELECTED AREAS

INVESTIGATOR: Arnold Krochmal
Southeastern Forest Experiment Station

SUMMARY OF PROGRESS: A collection has been made of most visible plants at Mount Pisgah Campground, and these have been pressed and identified.

The information collected would make an excellent visitor's plant guide to the Mount Pisgah Campground. A five or six page leaflet, mimeod perhaps, would be helpful to visitors who are not familiar with the plants at the campground.

# # #

CONTRIBUTION TO THE KNOWLEDGE OF THE HIGH ALTITUDE BEETLE FAUNA OF THE SOUTHERN APPALACHIANS

INVESTIGATOR: Lester L. Lampert, Jr.

SUMMARY OF PROGRESS: Collecting will start in the early spring of 1975 with collection of dormant overwintering adult beetles under bark, stone, moss, and leaf litter. Collecting will continue throughout the spring, summer, and fall until insect activity is ended by cold weather.

# # #

COLLECTING PLANT SPECIMENS FOR THE BOTANICAL HERBARIUM, U.N.C., CHAPEL HILL, N.C.

INVESTIGATOR: D. H. Krouse
Hendersonville, N. C.

SUMMARY OF PROGRESS: Various plant specimens were collected along the Blue Ridge Parkway areas, pressed, mounted and sent to the herbarium. Receipt was acknowledged.

# # #

RAPTOR RESEARCH; TO COLLECT DATA ON OCCURRENCE ON RAPTORIAL BIRDS FROM THE ASHEVILLE DISTRICT SOUTH ON THE PARKWAY

INVESTIGATOR: Shawn Knickerbocker
Cullowhee, North Carolina

SUMMARY OF PROGRESS: This project, which will begin on 1 December 1974, will be related to USFS project No. 11-00,116 already in progress. The purpose is to observe raptorial birds and ravens in the area of Devils Courthouse, Graveyard Fields, and Mount Pisgah, a part of Pisgah National Forest. Since the Blue Ridge Parkway is part of the national forest, this project may coincide with the USFS to obtain more valuable and detailed data on these birds.

This project is aimed at banding as many raptorial birds and ravens as possible. Its main objective is to determine if raptorial birds and ravens use the Blue Ridge Parkway as a major flyway or wintering ground.

# # #

GYPSY MOTH SURVEY - TRAPPING

INVESTIGATOR: William D. Jones

SUMMARY OF PROGRESS: Gypsy moth traps, baited with the sex attractant disparlure, were placed randomly along the parkway from MP-0 to the Virginia-North Carolina state line and in the Department of Interior campgrounds.

One male gypsy moth was recovered in Amherst County at the Little Otter Campground. This was the only find on Department of Interior property during the 1974 trapping survey.

# # #

AN ECOLOGICAL SURVEY OF BALDS ALONG THE BLUE RIDGE PARKWAY IN NORTH CAROLINA

INVESTIGATORS: James H. Horton) Western Carolina University
Lynn Gaines)

SUMMARY OF PROGRESS: We have made one trip to the parkway office in order to become acquainted with the various people there and Gaines has returned once to familiarize herself with the various resources of the office. Several subsequent visits will undoubtedly be required so that information included in the various reports on file there may be included in our study.

We have made three trips along the parkway to do preliminary botanical surveys. These have been day trips during which we visited the several balds to be included in the study and made general notes on the aspect of the balds, their species composition, and the apparent efficacy of the various sampling techniques which might be used in surveying them.

Gaines has visited the aerial photography laboratory in an effort to familiarize herself with the personnel and resources there. It appears that the dominance of their interest in agricultural lands may prevent their being of much help to us in this study. Consequently Gaines has initiated a search for aerial photographs of historical value through the NPS Science Center at the Mississippi Test Facility.

During the current academic quarter Gaines has engaged in a project comparing three vegetational sampling techniques: the quadrat method, the point quarter method, and the line intercept method. While this project was more closely related to her course work at WCU, it was selected so as to be of maximum value to her in connection with her park service work.

She has also engaged in a literature search which will provide the requisite background for this project. She has discovered and read to date three major articles on southern Appalachian balds. She has also read parts of three books and several additional articles on various methods of vegetational sampling.

Although there have been no significant findings to date, we believe the work is progressing satisfactorily. There seems to be no need to consider revisions of the planning at this time.

# # #

EVOLUTIONARY BIOLOGY OF SALAMANDERS OF THE GENUS *PLETHODON*

INVESTIGATOR: Richard Highton
University of Maryland

SUMMARY OF PROGRESS: During 1974, we did very little collecting along the Blue Ridge Parkway: more than half the 183 animals collected were taken beyond the actual boundary of the national park land at mile 80.9. The remainder were taken either near NC Rt 151 or mile 351.2 on the parkway.

# # #

GENETIC VARIATION IN FIELD CRICKETS OF THE GENUS *GRYLLUS*

INVESTIGATOR: Richard G. Harrison
Cornell University

SUMMARY OF PROGRESS: I collected crickets (*Gryllus pennsylvanicus*) along the parkway in September 1974 but, due to bad weather along the southern part of the parkway, I was unable to obtain all the specimens I wanted. The crickets I did collect (as well as others from Md., N.Y., and Ct.) were kept in cages until eggs were obtained, and were then frozen. I have not yet examined the frozen specimens from the parkway for enzymatic variation but tests on many other individuals have been run. Offspring from the eggs will appear this spring and will be reared under constant conditions so that an estimate of genetic variation in morphological and song characters can be made.

I intend to make further collections during spring and summer 1975, and I will be able to give a report on results after the next field season.

# # #

COLLECTION OF TABLE MOUNTAIN PINE CONES INFESTED BY *DIORYCTRIA TAEDA*

INVESTIGATOR: Thomas H. Flavell
USDA, Forest Service, Forest Pest Management

SUMMARY OF PROGRESS: We were unable to collect infested cones from trees along the parkway. Fortunately, an infestation was found on private land in Virginia so we were able to get the necessary specimens.

# # #

A MACROLICHEN FLORA OF THE HIGH-MOUNTAIN AREAS ABOVE 5000 FT IN THE SOUTHERN APPALACHIANS

INVESTIGATOR: Jonathan P. Dey
Duke University

SUMMARY OF PROGRESS: I am presently preparing the macrolichen flora of the Southern Appalachian high-mountain areas as my dissertation to be presented this coming spring for my Ph.D. The flora, comprised of approximately 175 to 180 species, will include identification keys, descriptions, natural-product chemistries, and discussions (where relevant) of all species. In addition to several interesting, significant range extensions, two new species have been described and one new nomenclatural combination has been formed. One interesting aspect of my research was the identification of several lichen species, known in North America only in the high-mountain areas of the Southern Appalachians, which are approaching possible extinction in the Southern Appalachians and in some cases in North America as the spruce-fir forest continues to shrink due to lumbering, fires, and more recently the devastation caused by infestations of the balsam woolly aphid, *Adelges piceae* Ratz.

My studies point out the need for a critical study of the lichens at lower elevations throughout the Southern Appalachians. Therefore, while essentially completing my original proposed research this coming year, I will be beginning a larger study of the macrolichen flora of the entire Southern Appalachian region.

# # #

GEOLOGY OF THE SKYLAND AND DUNSMORE MOUNTAIN QUADRANGLES IN WESTERN N.C.

INVESTIGATOR: Abdallah E. Dabbagh
University of North Carolina, Chapel Hill

SUMMARY OF PROGRESS: Three and possibly four phases of folding are recognized which correlate with polyphase deformation and metamorphism found elsewhere in the Blue Ridge and Brevard Zone. The earliest fold phase, F_1, is isoclinical, transposes original bedding, and produces schistosity S_1 in Blue Ridge rocks and mylonitic foliation in the Brevard Zone. S_1 is folded about horizontal N.30°E. trending F_2 fold axes lying in southeast dipping S_2 axial surfaces. S_2 is expressed as crenulation or slip cleavage grading into schistosity in the cores of F_2 folds. Locally S_1 is transposed by S_2 in schistose units. F_2 varies from rather open folds to tight sub-isoclines, particularly in the western part of the area where S_2 is deformed by F_3 folds with sub-horizontal axial planes (S_3). F_3 fold axes plunge 10° to the N.60°E. F_4 folds (possibly contemporaneous with F_3) produce gentle open warps of S_1, S_2, and S_3 (?) about subvertical northwest striking S_4.

Two distinct metamorphic events are associated with F_1 and F_2. The earliest progressive regional event, M_1, outlasted F_1 and attained the sillimanite grade. Syn-tectonic garnets are flattened in the S_1 plane while post-tectonic staurolite and kyanite cut across S_1. Kyanite is deformed and kinked by F_2. Sillimanite replaces biotite and muscovite and crystallized mimetically in S_1. The second progressive event, M_2, reached the staurolite grade. Biotite recrystallized in post-F_1 trondhjemite dikes and grew parallel to S_2. In schistose units staurolite grew randomly across S_1 and S_2 and across M_1 sillimantie fibers. Chloritization of biotite and garnet, saussuritization of plagioclase, and replacement of sillimanite, kyanite, and microcline by white mica represent a retrogressive M_3 event.

# # #

FLORAL INVESTIGATIONS OF SOUTHERN APPALACHIAN MOUNTAINS

INVESTIGATORS: I. W. Carpenter, Jr.)
Marie L. Hicks) Appalachian State University

SUMMARY OF PROGRESS: A master's thesis was completed, copy on file with Superintendent, concerning the flora of Sims Pond, Blue Ridge Parkway. A second master's thesis concerning the ecology of Boone Fork Sphagnum Bog was completed in 1972 and is on file.

An exhaustive investigation of the bryophyte flora is now underway centered at Linville Falls and the findings should be published late in 1975 or early in 1976. All collections are credited to the Blue Ridge Parkway and are deposited in the Appalachian State University Herbarium.

# # #

GEOLOGY OF THE MARION AND LITTLE SWITZERLAND QUADRANGLES, N.C.

INVESTIGATOR: James Robert Butler
University of North Carolina, Chapel Hill

SUMMARY OF PROGRESS: Geological mapping of the quadrangles has been nearly completed, and mineral resources have been surveyed. I am in the process of preparing maps and studying samples in the laboratory. The main results have been to clarify the geological structure of the areas.

Project should proceed as planned.

# # #

NATURAL AREAS INVENTORY OF SOUTHWESTERN NORTH CAROLINA

BLRI-N-22

INVESTIGATORS: Richard C. Bruce)
David Boufford)
Lynn Alan Schram) The Highlands Biological Station, Inc.
Emily W. Wood)
Diane Wickland)

SUMMARY OF PROGRESS: Summaries of potential natural areas are being written, and will be submitted soon to the state of North Carolina (Natural Areas Office, Division of State Parks). Plant material collected from the parkway by the investigators on this project has been deposited on the herbarium at the University of North Carolina, Chapel Hill. No further work on the Blue Ridge Parkway is anticipated at this time.

# # #

GENERAL ECOLOGICAL AND TAXONOMIC WORK

BLRI-N-22

INVESTIGATOR: Dorothy C. Bliss
Randolph-Macon Woman's College

SUMMARY OF PROGRESS: I am presently working on Liliaceae (Lily) family for the Virginia Flora Project. Most of this research involves study of plant specimens already in herbaria collections but I expect to do some field work.

# # #

THE POPULATION STRUCTURE AND ECOLOGICAL GENETICS OF THE LAND SNAIL, *TRIODOPSIS ALBOLABRIS*

INVESTIGATOR: Gary F. McCracken
Cornell University

SUMMARY OF PROGRESS: The genetic variation of *Triodopsis albolabris* throughout the species' range has been surveyed. It has been found that these animals are extremely variable, and that populations within the same forest and less than a kilometer from one another may have significantly different gene frequencies and in some cases different alleles at the same genetic loci. This sort of variation is determined by a population structure based largely on "founder effects" (where a population is started by a small and random portion of the gene pool, perhaps one or a few individuals) and by genetic drift. That this is the population strategy has been determined by intensive mark and recapture studies within populations to determine movement of individuals, and by mapping the distribution of populations.

It has also been shown that the southern 'subspecies' of this species complex, *Tridopsis albolabris major*, is actually a good species as it exists in Tennessee sympatrically with *T. a. albolabris* and they do not interbreed.

I have also shown that this animal can reproduce either through parthenogenesis or self-fertilization (I have not determined which yet). They were formerly believed to be obligate outcrossers.

# # #

COLLECT TWIGS AND BUDS (WINTER); LEAVES (SUMMER)

INVESTIGATOR: Frank H. Miller

SUMMARY OF PROGRESS: All field work has been completed, and every effort is now being made to complete the office work by 1 April 1975.

# # #

LIFE HISTORY OF PARASITIC SCROPHULARIACEAE

INVESTIGATOR: Lytton J. Musselman
Old Dominion University

SUMMARY OF PROGRESS: I was unable to do any field work on the parkway during the summer of 1974.

# # #

INSTRUCTIONAL FIELD RESEARCH TECHNIQUES FOR ADVANCED BIOLOGY CLASSES

INVESTIGATORS: Willis Eggler)
Henry Jensen)
William Penfound) Warren Wilson College, Swannanoa, N.C.
Charles Riddick)
Dennis Stockdale)

SUMMARY OF PROGRESS: The purpose of the project is to allow students in our field biology classes to study and collect modest quantities of native flora and fauna on the Blue Ridge Parkway. Instruction in collection technique occurs in the field, and instruction in identification in both field and laboratory. All materials collected are housed in the Warren Wilson College Biology Department Collection, and are available for inspection by anyone at any time.

The project is ongoing in nature, and the permit is renewed on a year-to-year basis.

# # #

VASCULAR FLORA OF THE CAROLINAS

INVESTIGATOR: J. Dan Pittillo
Western Carolina University, Cullowhee, N.C.

SUMMARY OF PROGRESS: Several plant species have been collected this year. Two habitats were of significance and should be protected: Mount Hardy and Pisgah campground bog. The former is above the parkway pavement and is beginning to receive some primative camping pressure. The plants of interest here are mainly beyond the favorable camp sites, however. The cliffs to the south are wet and difficult to traverse. The cliffs to the east are open and somewhat less difficult to walk on but do not offer many attractions. The Pisgah campground, however, is receiving far too much trampling pressure from campers and will require attention if the unique and rare plants are not to be harmed. This location urgently needs attention.

A list of collections has been submitted to the superintendent.

# # #

SURVEY OF VASCULAR FLORA OF THE CENTRAL VIRGINIA BLUE RIDGE MOUNTAINS AND STUDIES ON THE UNUSUAL VASCULAR EPIPHYTES

INVESTIGATOR: Gwynn W. Ramsey
Lynchburg College, Lynchburg, Virginia

SUMMARY OF PROGRESS: Survey of Vascular Flora. This is a continuing project which was started by Ruskin S. Freer many years ago. I have collected a number of vascular plant specimens within the parkway boundaries this past year and am preparing these specimens plus some others collected in past years for the Peaks-Of-Otter museum herbarium. My collecting in the past has been mostly in conjunction with the work of Freer. Since he is somewhat inactive now, future collecting will be done mostly in connection with field trips with students in the plant taxonomy course. None of the plants collected were of significance with exception to the unusual vascular epiphytes reported below.

Unusual Vascular Epiphytes in the Central Blue Ridge. This project was started in 1972 when several unusual epiphytes were found on Thunder Ridge and Apple Orchard Mountain. An article published in *Jeffersonia* was forwarded last year. In addition to the record reported last year we have found two more cases of black birch growing epiphytically on black oak. These two cases of epiphytism were observed between the Air Force Tracking station on Apple Orchard Mountain and Sunset Field to the south within the parkway boundaries. I am working on a grant proposal now which hopefully will result in the funding of this project. Kodachrome slides are used to record these cases of epiphytism along with actual herbarium specimens of the epiphyte and its host plant. Duplicate specimens will be placed in the Peaks-Of-Otter museum herbarium.

# # #

COMPARATIVE VEGETATION ANALYSIS OF FIVE SPRUCE-FIR AREAS IN THE SOUTHERN APPALACHIANS

INVESTIGATOR: S. Kent Schwarzkopf
Furman University, Greenville, S.C.

SUMMARY OF PROGRESS: A 117-page thesis paper was written during the fall based upon the research undertaken during the summer of 1974. The most significant findings of the research may be found in the 4-page summary and in the section on climate. The results of the actual field research are found in the "Results" section of the paper (pages 23-38) and in the various tables and figures (at the end of the paper). I know of no other study besides the one by Ramseur (basically a floristic one written in 1960) and mine that compares the spruce-fir areas of the Southern Appalachians. My study is basically concerned with the plant ecology of these areas. The five areas studies are: (1) the Great Smoky Mountains (Clingman's Dome area), (2) the Balsam Mountains (Richland Balsam), (3) the Black Mountains (Mount Mitchell), (4) Roan Mountain, and (5) Grandfather Mountain.

It is hoped that information gained from this study will be used in some way and not merely placed in the files. I plan to bring a copy of the paper to the office at Blue Ridge Parkway, Asheville, N.C., on 2 or 3 January before returning to Furman.

A total of 68 species (155 specimens) of vascular plants were collected as a part of this research. They are deposited in the Ives Herbarium of Furman University and various other herbariums. Few specimens were collected from Blue Ridge Parkway land; most were collected in Mount Mitchell State Park where I was involved in some naturalist work during the summer.

# # #

GEOLOGICAL STUDY OF THE BLUE RIDGE

INVESTIGATOR: Edgar W. Spencer
Washington and Lee University

SUMMARY OF PROGRESS: Preliminary field mapping of the Snowden Quadrangle was completed this year in the area of the James River Face "Wilderness Area." About half of the 15-minute sheet remains to be completed, but most of that is located in the Precambrian terrain. Field work was carried out primarily by Kevin Coppersmith under the direction of E. W. Spencer.

# # #

SURVEY OF TERRESTRAIL INVERTEBRATES OF NORTH CAROLINA

INVESTIGATOR: Rowland M. Shelley
North Carolina State Museum

SUMMARY OF PROGRESS: This is a continuing investigation designed to produce taxonomic and ecological data regarding the terrestrial invertebrates of North Carolina. Current efforts are centered around the arthropod class, Diplopoda. With the recent expansion of the research division of this institution, however, there will be a need to work more thoroughly with other groups. There is really no completion to this type of project (although individual sub-projects are terminated), and hence items 5 and 6 are not applicable. A paper revising the *Sigmoria latior* complex of millipeds is currently being prepared. A few Blue Ridge Parkway collections made by others are included, and reprints will be furnished when available. No collections were made on the Blue Ridge Parkway during 1974.

# # #

BOTANICAL SURVEY (GENERAL) ALLIGHARY CO., N.C.

INVESTIGATOR: John L. Mackay
Appalachian State University

SUMMARY OF PROGRESS: Sixty-three species of vascular plants were collected. All specimens are presently included in the herbarium of Appalachian State University, (I. W. Carpenter, Curator).

Additional information, including dates of collection, specific locations, etc., is available upon request.

# # #

INVESTIGATIONS OF THE GENUS *DESMOGNATHUS* IN THE SOUTHERN APPALACHIAN MOUNTAINS

INVESTIGATOR: Stephen G. Tilley
Smith College

SUMMARY OF PROGRESS: During the summer of 1974 several series of salamanders of the *Desmognathus ochrophaeus*-complex were collected along the Blue Ridge Parkway and transported to Smith College. These animals are being used in studies of the population genetics of this complex of salamanders. These studies involve electrophoretic analyses of genetic variation in the structures of enzymes and other proteins, and we are accumulating data on gene frequencies in many different populations of this complex. Eventually we will be able to calculate coefficients of genetic similarity between populations within and between different mountain ranges. These, in turn, will enable us to determine whether populations in the southern Appalachians are best treated taxonomically as a single species or several species. Our preliminary results indicate that populations in different mountain ranges may have very different genetic structures, indicating that the low valleys separating such ranges as the Black Mountains, Great Balsam Mountains, Nantahala Mountains, etc., may be effective barriers to dispersal of these animals.

# # #

BRYCE CANYON NATIONAL PARK

GENESIS OF THE UNUSUAL EROSIONAL FORMS OF THE BRYCE CANYON ESCARPMENT

INVESTIGATOR: Robert C. Lindquist
University of Florida, Gainesville

SUMMARY OF PROGRESS: Presently only preliminary field investigations have been undertaken with basic data recorded.

# # #

BUFFALO NATIONAL RIVER

TOTAL COLIFORM, FECAL COLIFORM, AND FECAL STREPTOCOCCUS CONCENTRATIONS IN THE BUFFALO NATIONAL RIVER

INVESTIGATOR: D. G. Parker
University of Arkansas, Fayetteville

SUMMARY OF PROGRESS: Water samples collected at eight permanent sampling stations and other selected sites in the Buffalo National River drainage basin were analyzed for total coliform, fecal coliform and fecal streptococcus concentrations (1). These three groups of test organisms are used as indicators of fecal contamination in surface and groundwaters.

The *Arkansas Water Quality Standards* for surface water suitable for primary contact recreation is, "Based on a minimum of not less than 5 samples taken over not more than a 30-day period, the fecal coliform content shall not exceed a log mean of 200/100 ml nor shall more than 10 percent of the total samples during any 30-day period exceed 400/100 ml." (2).

The log mean average of total coliforms at the eight stations ranged from a low of 67/100 ml at station 8, to a high of 1900/100 ml at station 3. The maximum concentration measured was 11,000/100 ml at station 3. The log mean average of fecal coliforms ranged from a low of <10/100 ml at station 8, to a high of 230/100 ml at station 3. The maximum concentration measured was 1600/100 ml at station 3. The log mean average of fecal streptococcus ranged from a low of 30/100 ml at station 8 to a high of 130/100 ml at station 3. The maximum concentration measured was 250/100 ml at station 5.

The fecal coliform:fecal streptococcus ratio has been used by some investigators as a means of separating human from non-human contamination. Water containing ratios greater than 4 are assumed to be contaminated by human feces while ratios less than 1 generally indicate non-human contaminations. (3)

Fecal coliform:fecal streptococcus ratios found in this study ranged from less than 1.0 for five stations, between 1.0 and 2.0 for two stations, and greater than 5.0 for one station (station 3).

The results of this study indicate that the Buffalo National River is receiving some fecal contaminations. Most of the contamination appears to be of non-human origin, however, one station may be receiving significant human fecal contamination. It is possible that some waters in the Buffalo River drainage basin may not meet Arkansas Water Quality criteria for primary contact recreation water.

Further study is needed to determine the extent of fecal contamination and to locate sources of this pollution. Also, further work would be required to establish how the water quality in the river compares with the existing Arkansas Water Quality regulations.

1. *Standard Methods for the Examination of Water and Wastewater.* 12th Edition, New York. American Public Health Association, 1965.

2. *Arkansas Water Quality Standards, Regulation No. 2, as amended.* Arkansas Dept. of Pollution Control and Ecology. September 1973.

3. Geldreich, E. E., and Kenner, B. A., Concepts of Fecal Streptococci. *Water Pollut. Control Fed. J.* R336. August 1969.

# # #

SHALLOW-WATER BENTHIC MACROINVERTEBRATES OF THE BUFFALO NATIONAL RIVER, 1974: A PRELIMINARY REPORT

INVESTIGATOR: Eugene H. Schmitz

SUMMARY OF PROGRESS: The Buffalo National River, Arkansas, was sampled for shallow-water benthic macroinvertebrates on 24 and 25 June 1974. The purpose of this investigation was to establish a single point-in-time qualitative survey and a quantitative estimate of such organisms subsequent to the 1973 preliminary reconnaissance survey. Since the three 1973 sampling periods occurred both during and immediately following the scouring effects of frequent flooding and fluctuating water levels, care was taken to select a 1974 period that was at least 2 weeks removed from such conditions. Organisms were taken along the Buffalo River from Boxley, Arkansas to Rush, Arkansas from eight sampling stations selected for the 1973 study. Sampling procedures utilized the same qualitative and quantitative methods outlined by Schmitz (1973).

The Turbellaria, Hirudinea, and Amphipoda were insignificant, their occurrences being scattered and isolated. However, the turbellarian, *Dugesia* sp., was taken in Surber samples at station 3. Although not observed during 1973, the appearance of the cosmopolitan amphipod, *Hyalella azteca*, in backwaters and isolated pools away from main currents is not surprising. The Oligochaeta were present at all sites, except station 1, occurring either in qualitative samples or in quantitative samples, but never in great numbers; their presence suggests a fairly stable to semi-stable substrate in shallow water, which furnishes an adequate supply of organic material to at least sustain a minimal population. On the other hand, it may be noted that the oligochaetes are substrate borrowers and are not directly subject to the mechanical action of the current in the determination of their distribution, except where such forces bring about shifting and other substrate changes.

The decapod, *Orconectes* sp., was recorded for all stations except 7 and 8. During 1973, crayfishes were observed in various stages of their life history at all stations. However, their apparent absence from stations 7 and 8 in 1974 may be sampling error, particularly as a result of relatively low densities. These animals tend to inhabit sluggish to still waters but may occur in areas of swifter water hidden under various submerged objects or in crevices between stones. Moreover, they are likely to range in very early morning, remaining quiescent or hidden during the day. Their appearance in Surber samples must be considered coincidental.

The Ephemeroptera presented the greatest diversity among all groups recorded. Of the 12 genera observed, *Stenonema* sp. was the most ubiquitous form, being represented at all sites except station 1. Likewise, the greatest densities were presented by members of this group, although it may be noted that the Oligochaeta contributed a close second at station 3. While there is no direct supporting evidence based upon a single collection, the predominance of mayfly nymphs, both in terms of diversity and density, may well represent a seasonal phenomenon. The great majority of nymphs taken were early instars indicating that the sampling period occurred during the second generation of pre-emergent forms for most species present. Therefore, the standing crop biomass contributed by the Ephemeroptera could not be interpreted to be as great as that constituted by certain other groups characterized by lower densities and diversity. The appearance of significant numbers of *Centroptilum* sp. in Surber samples but not in qualitative samples could not be reconciled.

Although not contributing significantly to overall densities, the Odonata presented a considerable increase in diversity over 1973 with four additional genera of dragonflies being recorded. Two of these (*Gomphus* sp. and *Neurocordulia* sp.) were taken as adults, which, considering their well-developed capacity for flight over considerable distances, introduces the possibility that these two genera may not have passed their aquatic nymphal stages in the Buffalo River. Qualitative sampling revealed that the distribution of Odonata nymphs was scattered and without apparent pattern; it may be noted that no nymphs were recorded for stations 7 and 8. Indeed, the general paucity of Odonata nymphs must be recognized. Whether or not Pennak's (1953) notation that ". . . The naiads are commonly found on submerged vegetation and the bottoms of ponds, marshes, and streams, and in the shallows of lakes but are rare in polluted waters. . . ." is appropriate here cannot be stated on the basis of our meager evidence. The naiads, being predatory on other freshwater invertebrates, may be limited in terms of food supply when the overall low benthic productivity in shallow-water areas of the Buffalo River is considered.

While generally distributed throughout the main river system, the relatively low densities and diversity of both Plecoptera nymphs and Neuroptera (=Megaloptera) larvae recorded both for 1973 and 1974 cannot be dismissed as an accident of occasional or one-shot collections. Such sampling patterns could be expected to reflect the overall situation relative to these two groups, for most Plecoptera are thought to spend at least 1 year in aquatic nymphal stages, and Neuroptera may spend 2 or 3 years as aquatic larvae (Pennak 1953). It is possible, of course, that both groups are represented in greater abundance in deeper regions of the river which were not included in the 1973 and 1974 studies.

The Coleoptera ranked second to the Ephemeroptera in terms of overall diversity but it must be noted that 8 of the 11 genera recorded were aquatic adults, which also have aquatic larval stages in their life histories. Our information does not provide us with any kind of explanation as to why larval stages of the majority of genera observed as adults were not taken. No clear distributional patterns could be discerned, although *Psephenus* sp., *Stenelmis* sp., and *Lutrochus* sp. were the most commonly encountered forms. The rather low density of beetles could well be reflective of the relatively high trophic level occupied by most forms observed. The greatest density corresponds with the greatest diversity at station 2.

Two characteristic swift-water trichopterans, *Cheumatopsyche* sp. and *Hydropsyche* sp., as well as the unidentified psychomiid larvae, were generally distributed. The hydropsychids were the major contributors where significant densities were recorded. *Chimarra* sp. and various unidentified forms were of minor importance and of scattered and isolated occurrences. Previous studies, particularly of trout streams, have shown trichopteran larvae to be an important item in the diet of game fishes.

The Chironomidae were the major components of the dipteran fauna, with the exception of station 5 where the Simuliidae were the significant contributors. The only Tabanidae observed were taken from station 8.

The isolated record of Hydracarina from station 5 should not necessarily be interpreted as a paucity of water mite fauna. Because of their very small size, most individuals would pass through the collecting nets used. Thus, their appearance must be considered accidental in these samples, due to adherence to debris or larger organisms.

Representatives of the Gastropoda and Pelecypoda showed a rather general distribution, although their overall absence from quantitative samples suggests, at least in part, relatively low densities in the shallow-water habitats considered.

The total standing crop expressed in terms of organism density would suggest a higher level of benthic productivity for 24 and 25 June 1974 as compared to the same period in 1973.

However, such an interpretation must be approached with extreme caution since (1) the 1974 sampling period occurred 2 weeks subsequent to appreciable rainfall thus allowing some time for recovery and recolonization; (2) the three 1973 samplings were conducted during and immediately following the scouring effects of flooding and fluctuating water levels; and (3) the major contributors to density and diversity were the Ephemeroptera, which may reflect a seasonal phenomenon characteristic of the time of year selected for sampling rather than the total benthic picture on an annual cycle. Moreover, this single sampling period was restricted to shallow-water benthos. Conceivably, the substrates of other habitats, such as extensive deep pools or deeper swift channels, sustain a substantial level of behthic production.

Inasmuch as most shallow-water benthic forms recorded for the 1974 sampling period were also observed in 1973, it would seem that the single point-in-time or short-term summer type survey have served their purposes. If more extensive knowledge of the benthic fauna and especially benthic productivity is needed, studies involving monthly samples throughout the year and intensive summer studies of secondary production in deep-water habitats, as well as shallow-water habitats, are desirable. Studies to this extent may contribute significantly to interrelated and on-going fisheries research on the Buffalo River, and as such, should be advanced for priority consideration.

I am indebted to Research Assistant Paul D. Kittle, whose able, enthusiastic, and conscientious efforts in the field and laboratory culminated in the compilation of this data. The assistance of John T. McCraw in the field and laboratory, and of Edgar D. Short in the field is gratefully acknowledged. This portion of the overall investigation was supported by funds from the United States National Park Service.

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# # #

VISITOR USE ANALYSIS--INCLUDING ANALYSIS OF REMOTE SENSOR DATA

INVESTIGATORS: H. McDonald
D. Parker

OBJECTIVE: Level II land-use mapping to be completed for the Buffalo National River watershed with special emphasis given to proposed camp sites.

SUMMARY OF PROGRESS: In order to accurately provide an insight to visitor use of "carrying capacity" for the Buffalo National River, many physical characteristics such as water quality, acreage, water depth and velocity, beach shoreline, fish, wildlife, soils, etc., must be inventoried. Because many of these parameters will not be known until later phases of the BNR Ecosystem Studies have been completed, the preliminary visitor-use analysis will draw heavily upon reconnaissance-type data and Level II land-use mapping.

Level II land-use mapping has been initiated for the entire Buffalo National River drainage basin. Remote sensing data analysis will include the use of panchromatic large scale aerial photography, color large scale aerieal photography, high altitude panchromatic photography, and Earth Resource Technology Satellite (ERTS-1) imagery.

The lack of topographic maps having a common scale for the entire watershed has caused base map problems; however, a standard-scale base map was compiled using county highway maps. Multiple copies of the base map have been reproduced.

The USGS land-use classification presently underway at level II includes the following categories:

Level I		Level II
Agricultural	21	Agricultural
Forest	41	Deciduous
	42	Evergreen
	43	Mixed*
Urban and Built-up	11	Residential
	17	Strip and clustered settlement
	12	Commerical
	13	Industrial

Land-use classification and definitions are from Geological Survey Circular 671, *A Land-Use Classification System for Use with Remote-Sensor Data* (1972), except for Mixed Forest Land.

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*Mixed Forest land includes all forest areas where both evergreen and deciduous trees are growing and neither predominates. It is Mixed Forest land when more than one-third intermixture of either evergreen or deciduous species occurs. Less than one-third intermixture results in classification of dominant type, whether evergreen or deciduous. (from proposed revision of Geological Survey Circular 671)

# # #

HEAVY METAL GEOCHEMISTRY OF BOTTOM SEDIMENTS FROM THE BUFFALO RIVER

INVESTIGATOR: Kenneth F. Steele
University of Arkansas

SUMMARY OF PROGRESS: Knowledge of the sediment chemistry of the Buffalo River is important because the sediments are in dynamic equilibrium with the water. The sediments are the foraging area for bottom feeding organisms and source of elements for rooted aquatic plants. They provide a reservoir for soluble pollutants via corrosion and for suspended pollutants via erosion or turbulence. The Buffalo River flows generally northeasterly, draining predominantly shale, limestone, and sandstone in the lower drainage region. Many inactive mines and mineral deposits of zinc, lead, and copper are scattered throughout the drainage area. Mining activity started in 1851 was most active in 1914 to 1917 but has been inactive for many years (McKnight 1935). Tailings piles near old mill sites still exist in a few places such as at the confluence of Rush Creek where over 25,000 tons of concentrates, mostly zinc carbonate with small amounts of zinc sulfide and silicate, were produced. Lead mineral areas occur mostly in the headwaters, and the major zinc mineralized areas occur along the lower portion of the river. Copper ore is very minor.

The metal contents of the sediments reflect the geology of the river. Sodium and potassium are higher upstream, probably due to small amounts of clay in the sediments, reflecting the shale environment. Iron and iron-associated elements (Cu, Ni, Cr, Mn) are in the highest concentration upstream. Shale is known to contain larger amounts of heavy metals than other sedimentary rocks and should make two contributions to the metal content of the sediments. First, fine particles of shale, or clay from the shale, could be in the sediments. Second, the ground water upstream should have a higher concentration of dissolved metals and ferrous iron due to contact with more shale. When oxidation occurs, the iron is deposited as hydrous ferric oxide on the stream sediments along with other metals by coprecipitation and sorption.

Downstream the concentrations of calcium and magnesium increased in the sediments. This is expected from the increase in limestone and dolomite downstream. Lead, zinc, and cadmium concentrations follow the known mineralogy and mining activity; lead is greatest upstream where there are more known lead deposits, zinc and cadmium are highest near the Rush Creek zinc mining area and downstream from it.

Procedure. Sampling of the sediments was carried out over the lower 130 miles from Boxley to Buffalo City. Twelve sampling stations were established. Stations 1 to 8 were each sampled in May and June and all were sampled in July of 1973. Float trips for much closer sampling of the lower 60 miles of the river were made in February, June, and July of 1973.

Sediment samples were taken from the river bottom or bank, generally just below the water line. Sediments were dried and sieved using a -95 mesh nylon screen. Petrographic analyses indicated the -95 mesh material was primarily quartz and chert with quartz predominating. A total of 77 samples were obtained and the -95 mesh sediment acid extracted with aqua regia and analyzed by atomic absorption for the following 13 elements: Na, K, Mg, Ca, Fe, Ni, Mn, Cu, Dr, Cd, Co, Pb, Zn. The first four of these elements are related to the geology of the area, whereas the last nine are potential pollutants and some are related to the area's mineralogy. Selected samples were also analyzed for mercury and arsenic. Oxide coatings on the grains and sulfide and carbonate clasts are the most likely materials dissolved by aqua regia.

Variation along the river (close sampling). The lower 60 miles of the river was closely sampled on 20 and 31 July 1973. Particular attention was given to all tributaries where sediment samples were taken on the downstream side of their confluence with the Buffalo River. Peak values for calcium plus magnesium and for zinc occur at two old zinc mining areas, Kimball Creek and Rush Creek. There is fairly good concordance between the peaks for calcium plus magnesium and for zinc, lead, and copper. These peaks occur also more or less in phase with the calcium plus magnesium peaks, probably because mineralization is favorable in the dolomitic rocks. Old mill tailings at Kimball Creek and Rush Creek may also be influential. Peak values of metals can return to background values within a mile. This results because the unique sediments from a tributary give high values near the mouth but are diluted further along the main river by less unique sediments of the main channel.

Chemistry. Our previous data and discussions have focused on the river bed as a chemical system. The chemistry and mineralogy of the sediment grain will now be discussed. The extractable amounts of potassium, magnesium, cobalt, manganese, chromium, nickel, lead, copper, zinc, and calcium were related to the extractable amount of iron in the same sample of -95 mesh sediment. Data from 77 samples were used. Samples taken in a tributary were examined separately. These were taken about 100 yards upstream into the tributary. All of the elements exhibit a linear relationship with iron concentration--an increase in iron concentration yielded an increase in element concentration. Very high concentrations of the non-iron metals which are well above the average are believed to be due to mineral clasts of these elements in the sediments. This occurred with magnesium, calcium, zinc, cadmium, copper, and lead. All of these have mineral occurrences in the Buffalo River drainage area. The minimum to average values are believed to be associated with a hydrous iron oxide coating on the sediments. Thus, for magnesium, calcium, cadmium, zinc, copper, and lead it is proposed that they exist and are transported as clasts as well as in the oxide coating of the sediments. These metals exist in mineral clasts primarily in the low iron, high calciferous environment which is the more mineralized area of the Buffalo River. Other metals studied here, cobalt, manganese, chromium, nickel, and potassium, are apparently carried in the ferric oxide film with no evidence for clasts.

Environmental implications. Only a cross section of the samples representing the main length of the river were analyzed for arsenic and mercury. Samples from Kimball Creek, Clabber Creek, and Rush Creek were included because they are from zinc-mining areas and had high zinc values. Enargite (Cu_3AsS_4) has at least one occurrence in northern Arkansas. Two of these three samples from the zinc-mining areas had somewhat higher arsenic values but lower than that found in the shale district at Boxley. The overall range for arsenic was only 5-14 ppm. Mercury has a range of 0.02-0.049 ppm with the higher values at Boxley, Ponca, and Jasper in the shale and lead mineralized area. Of three rock types (shale, sandstone, carbonates), shale has the greatest amount of each metal, except manganese which is greatest in carbonates.

Only three of the metals, zinc, lead, and cadmium, have high ranges in the sediments well above that for an average shale. The high values of 300-4000 ppm for zinc were all obtained in sediments at the confluence of tributaries draining old mining areas or known mineral deposits. Background values for zinc in the sediments were 50-200 ppm with the higher background values occurring in the lower one-third of the river which is just beyond Rush Creek, the principal zinc mining area. Cadmium values were on the average 8-10 parts/ 1000 parts of zinc, the same ratio which is found in the ores (McKnight 1935). Thus, cadmium highs corresponded to highs for zinc. Because of this constancy between cadmium and zinc it was concluded that they were transported as mineral clasts in the river. Lead background values were from 4-10 ppm as against the high range of 14-357 ppm found at the confluence of tributaries draining lead-mining areas. These tributaries were in the headwaters of the Buffalo River in the Boxley-Ponca area. Perhaps attention should be given to ensuring stabilization of ore and tailing piles in these old lead- and zinc-mining areas in order to minimize pollution of the Buffalo River sediments.

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# # #

SPATIAL AND TEMPORAL DISTRIBUTION OF ALGAE, WITH ASSOCIATED PARAMETERS, ALONG THE BUFFALO RIVER, ARKANSAS

INVESTIGATOR: Richard L. Meyer
University of Arkansas

SUMMARY OF PROGRESS: The algae populations along the Buffalo River occur in two major communities: the free-floating phytoplankton and the attached periphyton. The phytoplankton community includes those species which complete their life-cycle in the planktonic state, the euplankton, as well as a large number of tychoplankters or chance-plankters. The periphyton community develops upon a series of diverse substrates. Certain species are common to all substrates while others display strong substrate selectivity. The subcommunities recognized in the riverine system include those species attached to plants or animals, epiphytic or epizooic; those associated with rocks, epilithic; and organisms which form a film at the soil-water interface, epipelic.

The assemblages of organisms associated with these various subcommunities varies with changes in physical and chemical inputs. The principal physical parameters effecting distributional patterns are insolation, temperature, current, and turbidity. The concentration of certain chemical components also have an impact on qualitative and quantitative characteristics of the algal flora. The algal population present within the stream system reflect the integrated influence of the numerous physical and chemical as well as biological parameters. For example, development of a snail population, which are grazers, may also serve as substrate, thus directly influencing distributional patterns of selected species. The emergence and development of aquatic phanerogams modifies the stream velocity and provides substrate for sessile forms. The seasonal appearance of these vascular plants restricts certain algal species.

The objectives of the phycological research program are directed toward describing the qualitative and quantitative temporal and spatial aspects of communities and subcommunities along the Buffalo River. Physical, chemical, and biological parameters are integrated with the phycological analysis to determine the importance of the various inputs. The portion of the research program reported in this presentation is directed toward a broad perspective of seasonal trends, spatial trends, and subcommunity associations.

MATERIALS AND METHODS: Algal and chemical collections were taken at the eight standard stations described by Babcock and McDonald (1973).

Phytoplankton samples were collected with a 15 cm diameter, 25 mesh hand-held net. Grab samples from other subcommunities were collected; live and M_3 preserved material was retained for microscopical examination.

Samples for chemical analysis were collected in plastic bottles. Ammonium concentration was determined on raw water samples, while nitrates, orthophosphate, and silicon concentrations were measured after filtration. Ammonium-N was determined with an Orion specific ion probe. Nitrate-N was determined by the ultraviolet method (Standard Methods 1971). Silica concentration was determined by the heteropolyblue method described in APHA (1971). A Hach Analytical Nephelometer Model 2100A was used to measure turbidity.

RESULTS AND DISCUSSION: The water temperature remains relatively stable from late May through late July with a mean temperature of 21°. As the flow decreased in the summer a rapid increase in temperature was observed. An increase of 7° in the mean temperature occurred with only a 5° increase in minimum reading and a 10° rise in maximum temperatures. A thermal gradient developed along the rivers' reach. The maximum readings occurred in shallow, quiet pools near solar noon. The temperatures returned to spring levels by mid-September, 18 ± 2°. The temperature continued to decline in October to 15 ± 1° in the stream with maxima of 18-20° in shallow pools.

Adjacent riffles and pools within the flowage tended to have the same temperature. In spring, early summer, and fall the stream is nearly isothermal. In summer and early fall the lower stations are 3-4° warmer than upper Buffalo River sites. Thus, only during this latter period might water temperature be considered important in determining the spatial distribution of algae. Localized warming in isolated lateral pools may, however, result in isolated populations.

The entire stream receives equal mean insolation and solar duration. Due to the clarity (0.29-0.91 NTU's) and shallowness of the stream, light probably exceeds saturation levels. Only during flood periods might light-intensity become limiting. Day-night length may be an important parameter in determining temporal distribution but would not effect spatial distribution.

The concentration of Ammonium-N was stable throughout the sampling period and along the length of the river with mean values from 0.002 to 0.005 mg/l. Apparently this ion does not influence the distribution of the algae.

Nitrate-N concentrations ranged between 0.16-0.36 mg/l with mean values between 0.19 and 0.30 mg/l during most of the sampling period. In September however the concentrations were approximately double previous values. This increase in nitrate corresponded closely with the onset of abscission layer formation in the terrestrial vegetation. The reduction in transpiration was reflected in the increased flow of ground water and springs. The ground waters of Arkansas usually contain elevated levels of nitrate. The reduced concentration in October was probably a result of dilution by fall rains. The abrupt change in nitrate concentration may be a factor in initiating the summer to winter assemblage succession.

Filterable orthophosphate-P levels remained low throughout most of the sampling period with mean concentration between 0.010 and 0.073 mg/l. The last collection, October, had consistently higher values. The orthophosphate concentrations are negatively correlated algal abundance. The density of phytoplankton and periphytic form was drastically reduced throughout the river system during the period of maximum concentration. The elevated concentrations of phosphate could indicate a lowered requirement due to reduced population size and/or a decrease in metabolic rate. The latter effect would be influenced by shortened day length and lowered temperatures.

Spring and summer algal populations include an abundance of green and blue-green algae with fewer diatoms. These earlier populations are replaced by diatom assemblages in the fall. The development of these fall-winter assemblages was refelcted in the concentration of silicates. The silicate concentrations remain above 4.5 mg/l from May through August. However during late summer and fall, concentrations decreased to slightly greater than 3 mg/l. These levels are consistently above limiting concentration by at least two orders of magnitude.

A review of the temporal occurrence of major taxa suggests a qualitative periodicity. Certain taxa tend to be more common under certain chemical, physical, and biological conditions. The Chlorophyceae, with few exceptions, are usually collected in early summer with the Volvocales almost exclusively restricted to this period. Only a limited number of genera extend through the thermal maximum. *Scenedesmus* spp. and *Oedogonium* spp. are examples of genera which are found throughout the season although the species may not be constant. The distribution of *Oedogonium* spp. is closely associated with the phanerogams. *Gongrosira* appear in greatest abundance during the thermal peak while *Bulbochaete* develop at minimum water temperatures. The distribution of the filamentous Congujatophyceae appear during August and is reduced in October. *Spirogyra* also occurs less frequently and with reduced abundance after the onset of fall conditions. Unicellular members of this class tend to be present early and late in the season. The Euglenophyceae are localized in occurrence. A dense mixed population of euglenoids was observed in a warm pool (30°) at a single site. The dinoflagellates and chrysophytes were encountered too infrequently to recognize a pattern of distribution. The single xanthophyte, *Vaucheria*, was discovered during the fall at a limited number of sites. The centric diatoms as well as most of the pinnate genera occurred before and after the thermal maximum. The greatest frequency of occurrence and abundance was in the autumn. *Cymbella*, *Epithemia*, *Gomphonema*, and *Synedria* species were usually present throughout the sampling period. *Cocconeis* and certain other epiphytic organisms were dependent on the distribution of the Oedogonales and Cladophorales. The Cyanophyceae were generally present throughout the study period except for September. The greatest number of these genera were recorded prior to the maximum temperature. *Calothris*, however, was first observed at most stations at the time of maximum temperatures. This genus continued to be present into the fall. The cyanophytes were conspicuously absent or reduced during September, only to return in October. Water temperature apparently is not a controlling factor but increased nitrate concentrations may restrict certain genera. Three genera of freshwater Rhodophyceae have been reported from the Buffalo River. These rare or uncommon genera are typically found during the winter and spring. Two genera, *Asterocystis* and *Audouinella*, were collected in warm water epizooic on snails.

The spatial distributional patterns are less easily discernable at the generic and higher taxonomic level. However, our observations indicate that there are distinct species differences at various sites. Further analysis of the data probably will suggest segmenting the river into several compartments with similar characteristics. The more abundant representatives tended to be delimited by habitat rather than position, i.e., station. The riffles tended to contain similar organisms without regard to position. The pool reflected a similar pattern. This habitat-controlled distribution pattern was observed in the previous study (Meyer *in* Babcock and McDonald 1973) and was applicable during lower water temperatures. The greatest spatial diversity developed in late July and August which paralleled the temperature gradient. A 4-6° rise in water temperature was recorded between the upper and lower Buffalo River during this period. The spatial differences observed in the summer season occur with the high-use period. Thus a more intensive collection program and careful analysis of data will be necessary before cause and effect relationships can be established.

Acknowledgements

I am indebted to Laura Rippey for her personal interest in gathering samples and providing valuable field and laboratory data.

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# # #

WATER CHEMISTRY INVESTIGATIONS OF THE BUFFALO RIVER AND ITS MAJOR TRIBUTARIES

INVESTIGATOR: Joe F. Nix
Ouachita Baptist University
Arkadelphia, Arkansas

SUMMARY OF PROGRESS: Two intensive water chemistry investigations of the Buffalo River and its major tributaries have been conducted, the first between 22 and 27 May 1973; the second between 26 May and 1 June 1974. Collection of field data and water samples was made by floating the entire river in canoes and sampling the river at approximate intervals of 4 miles and tributaries at their confluence with the river. The entire field reconnaissance was spread over 6 days on both trips.

Temperature, dissolved oxygen, and specific conductance were measured *in situ* and pH was measured immediately upon collection of the sample. Alkalinity was measured in field laboratories at the end of the day. Raw water samples were transported to the Water Chemistry Laboratory at Ouachita University where they were analysed for sodium, potassium, calcium, magnesium, iron, manganese, zinc, chloride, fluoride, sulfate, orthophosphate, and nitrate.

Immediately prior to and during the 1973 survey, rain showers were experienced throughout the entire Buffalo River watershed. Significant rain had not occurred for several days prior to the 1974 study, and only very light showers were experienced on 1 day during the study. It was estimated that the flow of the Buffalo River was slightly lower during the 1974 study. It was necessary to terminate the 1973 study near river mile 33 due to an intense storm and a rise of the river.

The temperature of the Buffalo River ranged from 16°C to 28°C on both reconnaissance trips. A temperature gradient seems to be established with cooler temperatures in the upstream section of the river. Since investigations were spread over several days, it was impossible to show conclusively that this gradient existed or if the river was simply warming during the course of the study. Diurnal warming was observed, except during periods of cloud cover.

Dissolved oxygen concentrations were observed to range from 8 ppm to 12 ppm with the highest concentrations being observed during the maximum period of sunlight intensity and the lowest values early in the morning.

Specific conductance data indicated that the total dissolved solids concentration of the Buffalo River increases significantly in a downstream direction with values near 50 micromohs being observed in the upstream section and values approaching 300 micromohs being observed in the downstream section of the river. Instrument failure prevented collection of specific conductance data below river mile 65 during 1973. The data for the entire river, collected in 1974, showed a significant drop in specific conductance near river mile 80. The values for alkalinity as well as those for magnesium and calcium, showed similar patterns as that for the specific conductance. The concentration of both magnesium and calcium decreased significantly near river mile 80.

The concentration of calcium in tributaries above river mile 120 is relatively low (less than 20 ppm). From this point, calcium concentrations increase significantly to values near 80 ppm. Richland Creek, a major tributary of the Buffalo, enters the river near river mile 80 and has a calcium concentration of only 15 ppm. The decrease in calcium concentration (as well as magnesium and alkalinity) is obviously due to dilution from Richland and possibly other smaller tributaries in this section of the river. Near river mile 80 the Buffalo leaves a section of predominately St. Peter Sandstone and Everton Limestone. From this point it flows through a slightly younger geological formation dominated by a variety of shales, sandstones, and limestone for a distance of approximately 20 miles. This discontinuity in principal rock types coincides with the break in calcium and magnesium concentration in the river. The watershed of Richland Creek is almost totally dominated by this younger formation. It would appear that the older Everton Limestone contributes more calcium to the Buffalo River than other formations. (Arkansas Geological Survey, Geological Map of Arkansas)

A plot of calcium concentrations vs. alkalinity data obtained on the 1973 investigation for the mainstream of the river seems to follow a straight line, while the values observed for tributaries, in addition to being higher, follow a straight line of different slope. These data suggest that tributaries are enriched in bicarbonate species relative to calcium and may indicate that there is a higher percentage of ground water in the tributaries. A plot of calcium concentration vs. sulfate concentration suggests that gypsum is the origin of sulfate in the river system.

The concentration of sodium, potassium, and chloride was observed to be somewhat erratic during the 1973 study, while during the 1974 investigations, almost constant values were observed from the upstream section of the Buffalo to its confluence with the White River. Since considerable rain had occurred throughout the watershed of the Buffalo prior to and during the 1973 study, these data may indicate that these parameters are only introduced in significant concentrations during periods of elevated flow. The difference in the two sets of data is striking. Another parameter which seems to reflect the introduction of runoff is iron. The iron concentration of samples taken from the Buffalo was determined by direct aspiration of raw water samples into the flame of an atomic absorption spectrometer. Since unfiltered samples were used, these data reflect essentially total iron and the excessive concentrations probably represent the presence of silt.

One sample taken during the 1973 study near river mile 60 was anomolously high in several of the constituents measured. Since this observation was made for only one sample, it is difficult to place any significance to this anomolous concentration. With the exception of this one sample, the concentration of zinc in the mainstream of the river ranged from less than 0.01 ppm to near 0.3 ppm. Some higher concentrations were observed for tributaries which drain abandoned zinc-mining areas.

Data suggest that there may be some introduction of nitrate in the vicinity of river mile 60. The importance of the single anomolously high concentration observed near this point in 1973 was strengthened by the observation of slightly elevated nitrate concentrations in this same section of the river in 1974. These slightly higher nitrate concentrations may originate from agricultural fertilizers.

Again, with the exception of the one anomolous sample near river mile 60, the orthophosphate concentration was observed to fluctuate between 0.01 and 0.10 ppm (as PO_4) during 1973. The range of values observed in 1974 was similar but a distinct increase in the phosphate concentration in the lower section of the river was apparent. Such a gradient could originate from runoff from agricultural areas or from natural geochemical reactions.

This study has provided data that help to establish the chemical nature of the Buffalo River system during a limited period of time. Data on seasonal fluctuations on major parameters are being collected by other investigators. To understand the major factors affecting the introduction of various chemical constituents into the river system, data on the response of the river to a major storm event are needed.

# # #

THE VASCULAR FLORA OF LOST VALLEY, NEWTON COUNTY, ARKANSAS

INVESTIGATOR: Ralph Luther Thompson
Southwest Missouri State University
Springfield, Missouri

SUMMARY OF PROGRESS: Vascular plants of Lost Valley (formerly Lost Valley State Park) were collected, pressed, identified, and classified according to Steyermark's *Flora of Missouri*. As of 22 December 1974, some 102 families and 604 species were represented in the preliminary survey.

Lost Valley is a unique area containing several relics or disjuncts of the Appalachian Mountain region. The vegetation conforms to the mixed mesophytic forest association.

Lost Valley and its floral elements need permanent protection and preservation to maintain their natural beauty. The small park area should have signs with regulations posted as to pollution, fires, cutting of woody plants, and destruction of wildflowers.

It is my opinion and desire that the Lost Valley park area should be set aside by the Buffalo National River authorities as one of the areas to be a natural wilderness and scenic area and to be kept in its natural condition as much as possible.

# # #

GENERAL COLLECTING OF VASCULAR PLANTS AND BRYOPHYTES

INVESTIGATOR: Paul L. Redfearn, Jr.
Southwest Missouri State University

SUMMARY OF PROGRESS: I have not personally made any collections within the park region this year.

# # #

WATERFOWL SPECIMENS MOUNTED FOR EDUCATIONAL PURPOSES

INVESTIGATOR: Burke E. Thompson
Fernbank Science Center, Atlanta

SUMMARY OF PROGRESS: This project was designed to provide mounted specimens to be used in the science center's educational programs both in the classroom and the exhibit hall. All specimens collected in 1974 have been prepared and are now in use. The remaining needed species will be collected in February 1975, and will be prepared immediately. This will complete the project.

# # #

ECOLOGY OF SAND DUNES

INVESTIGATOR: W. W. Woodhouse
North Carolina State University

SUMMARY OF PROGRESS: The study now consists of one 7600 ft dune--building experiment established in February 1965 and a 1966 experiment covering about 5000 ft. Trials on revegetation of diseased spots have been superimposed on both experiments. Plans are to publish a report in 1975 on the development of these dunes since 1968. This will cover effects of species, seed supply, and sand supply on rate of dune growth, shape, and botanical composition. Plans are to continue to follow the development of these dunes and record significant changes as they occur.

# # #

CAPULIN MOUNTAIN NATIONAL MONUMENT

STUDIES ON THE EFFECTS OF GRAZING ON GRASSLAND UNDER PERMIT ON THE CAPULIN MOUNTAIN NATIONAL MONUMENT, NEW MEXICO

Installation of Exclosures and a Vegetative Survey within the Exclosures

INVESTIGATOR: A. L. Gennaro
Eastern New Mexico University, Portales

SUMMARY OF PROGRESS: In 1972, 95 acres adjacent to Capulin Mountain National Monument, New Mexico, were purchased by the National Park Service from the state of New Mexico. At that time, the 95 acres were under lease from the state by John Morrow and Carlos Cornay. To compensate for loss of income to those ranchers, the National Park Service agreed, under provision of Public Law 91-646, to reimburse Mr. Morrow three calves/year and Mr. Cornay one and a half calves/year. The National Park Service agreed to make a cash settlement or provide equivalent grazing under provision of Public Law 91-646. The latter was accomplished by designating two areas (one to each rancher) within the boundaries of Capulin National Monument to be used for grazing as long as such grazing proved not to be detrimental. The grazing status of each one is described as follows:

1. Area 1--under permit by John Morrow since 1972, but no grazing has occurred since that date. Permit is subject to renewal 1 September 1976. Grazing status prior to 1972 is not known.

2. Area 2--under permit since 1972 and has been grazed since that time. Permit is subject to renewal 1 March 1978. Grazing status prior to 1972 is not known.

The purpose of the first phase of this study is to establish two controls (exclosures) one in each of areas 1 and 2 and to conduct a vegetative survey within those exclosures. Phase two of this study will involve vegetative surveys outside and inside the exclosures during subsequent growing seasons to determine the effect of grazing on areas 1 and 2.

METHODS: Two 50 m X 200 m exclosures were established in May 1974. One was placed on area 1 and the other on area 2. Both were enclosed with a three-strand barbed wire fence. In addition, a study area of the same size was marked off by stakes on area 3. There are apparently no future plans to issue permits for grazing on area 3, and it has not been grazed since the park was established in 1916.

Species composition and ground cover percentage were determined within each plot by using 100-point paced transects as described in the Big Game Browse Range Analysis Techniques for New Mexico. Less than 1% of areas 2 and 3 contained shrubs; whereas, area 1 had at least a 1% coverage of shrubs and trees. Both annuals and perennials were recorded during the study.

RESULTS AND DISCUSSION: Vegetative data collected for this study were obtained during a year of below average precipitation on the Capulin Mountain National Monument. During January 1974, Capulin was 0.61 inches above average but from February through August, Capulin was 0.25, 0.26, 1.10, 2.08, 0.83, 1.3, and 1.29 inches below average, respectively. A precipitation dispersion diagram (Tuan *et al.* 1969) showing normal average monthly precipitation for Raton, New Mexico, 39 miles west of the monument, was used to determine the deviations from average precipitation at Capulin. Precipitation data for Capulin were obtained from United States Weather Bureau records. Data for September 1974 were not available during preparation of this report.

During a year of average precipitation one might expect a higher ground cover index for May than the data indicated for 1974. Also, low precipitation may account for the high percentages of litter and bare ground in the early part of the summer. Identification of plants was also difficult during early summer. For example, *Artemisia frigida* Wild; *Artemisia Carruthii* Wood; and *Artemisia ludoviciana* Nutt., listed in the September transects, were generally unidentifiable in the May and July transects and listed as *Artemisia* spp.

The highest number of plant species was counted in July on all three plots. The low number in May was probably a result of low soil moisture; the low number in September was probably a result of running only one transect per exclosure. Tree and shrub species had approximately a 1% coverage within the plot area 1, including *Pinus edulus* Engelm, *Quercus* spp., *Rhus aromatica* Ait., and *Cercocarpus montanus* Raf. *Pinus edulus* was the dominant tree species on area 1.

Data from the three plots from areas 1, 2, and 3 were also compared. *Schizachyrium scoparium* (Michx.) Nash., *Bouteloua gracilis* (H.B.K.) Griffiths, *Andropogon Gerardi* Vitman, and *Artemisia* spp. were dominants common to all three plots. Considering all species, twelve were common to all the plots, seven were common to plots 1 and 2, one to plots 1 and 3, and one to plots 2 and 3. Eight species were recorded only on plot 1; two species were recorded only on plot 2, and six species were recorded only on plot 3.

During this study, species patterns and composition within each plot were representative of areas outside the plots. These data from within each plot will be a basis for comparison to determine the effects of grazing outside the plots in years subsequent to 1974.

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# # #

CARLSBAD CAVERNS NATIONAL PARK

RANGE CONDITION SURVEY AND WILDLIFE BROWSE ANALYSIS, CARLSBAD CAVERNS AND GUADALUPE MOUNTAINS NATIONAL PARKS

INVESTIGATORS: Michael R. Glass)
Roger E. Reisch) National Park Service
Gary M. Ahlstrand)

SUMMARY OF PROGRESS: The importance of Carlsbad Caverns and Guadalupe Mountains national parks as a wildlife habitat is illustrated by the diversity of major vegetation types within their boundaries. Elevation ranges from a low of 3500 ft in Carlsbad Caverns to a high of 8750 ft at Guadalupe Mountains. The interspersion of wooded highlands and deep canyons contributes to numerous feeding and cover areas in close proximity. The scenic ruggedness, combined with abundant wildlife, offers a fascinating and diverse experience for park visitors.

Some evidence remains of heavy livestock use (primarily goats) in Carlsbad Caverns, although domestic use ended two decades ago. Lithosols and a semi-arid climate contribute to the slow recovery of vegetation. Range ratings for the lower range average a medium or stable condition and a medium high rating for the upper range. Range indicators show an upward trend for the park. Few individuals of preferred and staple species show damaging current use, least desirable species are rarely used, cool-season grasses and forbs are relatively abundant, and ground cover is steadily improving.

Guadalupe Mountains National Park contains within its boundaries some of the best wildlife range to be found in the area. However, evidence of heavy livestock use is still apparent in some portions of the park. These areas are recovering at a more rapid pace than at Carlsbad Caverns National Park, probably due to greater amounts of annual precipitation and deeper soils. Soil movement is presently apparent on the west side of the park, but increasing ground cover should slow this process in the future. Range ratings indicate a medium high condition for the upper and Dog Canyon ranges, a moderate upward trend for the west side range, and a medium or stable condition on the east escarpment range. The average rating for the entire park shows a moderate upward trend. Few individuals of preferred and staple species show damaging current use, cool-season grasses and forbs are relatively abundant, and the ground cover is increasing.

# # #

THE MICROCLIMATE IN CARLSBAD CAVERNS

INVESTIGATOR: John S. McLean
U. S. Geological Survey

SUMMARY OF PROGRESS: The microclimate in Carlsbad Caverns is primarily controlled by cold airflow into the Natural Entrance and down the Main Corridor during the winter, which displaces the warmer air in the cave. Atmospheric conditions in the cave are stable during the summer when warm air on the surface above the cave overlies the cooler cave air. Annual cycles in the cave microclimate are therefore characterized by a high rate of evaporation and air circulation during the winter and by high water levels in pools, increasing carbon dioxide content of the air, and high relative humidity in the late summer.

Uncontrolled airflow up the elevator shaft removed an estimated 833,000 litres (22,000 gallons) of water per year from the cave during 1970. The top of the elevator shaft is 18 m above the Natural Entrance, and thus acted as a chimney to expel warm cave air during the winter. During the summer, air was withdrawn from the cave to cool the Visitor Center at the upper terminus of the elevator shaft, increasing the evaporation during the otherwise stable summer period. In August 1972, revolving doors were installed at the bottom of the elevator shaft to control the air flow up the elevator shaft. This resulted in a net decrease in evaporation of at least 9%. Evaporation in the Pump Room, near the bottom of the elevator shaft, decreased 26% as a result of this installation.

Evaporation in areas of the cave remote from the elevator shaft increased an average of 10% from August 1972 to August 1973. This increase in evaporation is probably due to an increased amount of heat from the cave lighting system which accompanied the changeover from guided to self-guided tours in January 1972. The changeover resulted in the lights being on for a longer period of time with a resultant increase in power consumption. A series of regression equations indicated that the part of the evaporation which is correlated with power consumption was negligible at five locations and ranged from 14 to 63% of the total evaporation at the remaining four locations.

# # #

USE OF FIRE AS A MANAGEMENT TOOL

CACA-N-011a

INVESTIGATORS: Gary M. Ahlstrand) National Park Service
Michael R. Glass)

SUMMARY OF PROGRESS: Six phases of the ecology of fire research program at Carlsbad Caverns and Guadalupe Mountains national parks have been discussed. Evidence suggests that fire has been a greater influence on the parks' ecosystem in the past than has generally been recognized. Analysis of fairly recent burns in the area has shown that vegetation dynamics are altered on the site following fire, but that seral species typically do not become established on the burn. Information concerning conditions prior to, during, and after burning are needed to adequately understand the responses of vegetation to fire, and future studies of this nature will be conducted on well-documented experimental burns designed to also test various fire prescription formulae.

Seed germination work has suggested reasons for the relative success of some species in the Chihuahuan Desert region, but more detailed investigations are required to determine the ecological amplitudes for seed germination in some critical species. Investigations of plant-water relations have been started and information from this phase of the research will give new insight into adaptive mechanisms of certain species. These investigations may also lead to a new method of predicting potential fire danger in the area. The final phase of the research will examine the degree to which burning affects microenvironment energy budgets.

When results from all phases of the fire research are considered together, the resource manager will have a tool that can be used in numerous ways to achieve different management goals. In addition, the results from this research should be applicable with only slight modification to other areas in the Chihuahuan Desert region, such as Big Bend National Park.

# # #

CAVE INVENTORY, PROTECTION, AND USE (GROUND RECONNAISSANCE)
CACA-N-006a

INVESTIGATOR: Charles M. Peterson
National Park Service

SUMMARY OF PROGRESS: I have continued to systematically examine backcountry areas of the park for caves. With this I have visited many known caves up-dating their individual files.

One new cave was added to the park files bringing a total of 60 known caves. Due to breaking my arm, the long fire season and a lengthy training period I spent about 20% of my time on this ground reconnaissance.

I have arbitrarily set a 5 year time span for the ground reconnaissance and inventory of caves. During these years I will extensively cover the Caverns backcountry; however, one can be assured that new caves will continue to be found after this project is completed due mainly to the ruggedness of the park.

# # #

CAVE MAPPING AND SPELEOLOGICAL RESEARCH
CACA-N-005

INVESTIGATOR: Cave Research Foundation
Yellow Springs, Ohio

SUMMARY OF PROGRESS: A more extensive report is under preparation by the Cave Research Foundation and will be available during January 1975. The scientific programs to be discussed in this report are listed below:

Cartography Program - Primary objectives continued to be the control surveys and support surveys of cartographic and geological programs. This year a total of 2.2 miles of Brunton survey and 9.8 miles of control survey was completed in Carlsbad Caverns National Park. Total survey length in Carlsbad Caverns is 20.2 miles and 1.5 miles in the Rainbow/Ogle Cave system.

Geology Program - Numerous projects are in work and include the following:
- Mineralogy of Carlsbad Caverns and caves of the Guadalupe Mountains
- Structure and stratigraphy of Ogle Cave
- Speleogenesis in the Guadalupe Mountains
- Gravity survey at Carlsbad Caverns

Biology Program - The following projects are included in this area:
- Survey of the cave fauna of Carlsbad Caverns and Guadalupe Mountains national parks
- Survey of New Mexico cave fauna
- Activity rhythm of the Cave Cricket, *Ceuthophilus conicaudus* Hubbell

RECOMMENDATIONS: The work should proceed as planned with continuing expansion in the various scientific areas.

# # #

POPULATION DYNAMICS OF THE MEXICAN FREETAIL BAT
CACA-N-0013

INVESTIGATORS:
Kenneth N. Geluso)
J. Scott Altenbach) University of New Mexico
Don E. Wilson
National Museum of Natural History

SUMMARY OF PROGRESS: *Tadarida brasiliensis* populations are in a state of general decline in the southwestern part of the United States. This decline is especially apparent in the seasonal resident colony of *T. brasiliensis* at Carlsbad Caverns. As part of an investigation to determine the factors affecting this decline, data were gathered concerning the magnitude and causes of infant mortality in the nursery colony at Carlsbad Caverns for the 1973 and 1974 reproductive seasons.

In 1973, all fallen bats were collected from below the roost during two consecutive mornings at weekly intervals throughout the summer and fall. By constructing a graph depicting the number of infants that fell in 24 hours during each visit, infant mortality for each day could be estimated by interpolation. We estimated that the total number of fallen young represents less than 5% of the total number of young born. Forearms of all infants collected were measured to determine the size class (= age group) with the highest mortality. A histogram was constructed by dividing the range of forearm measurements into seven size class intervals and then determining the number of fallen infants belonging to each size class. The infants from the second size class (= infants from birth to 2-days old) had a significantly higher mortality.

As a preliminary investigation to see if the infant mortality pattern could be related to pesticides, whole body analyses for chlorinated hydrocarbons were run in fallen bats from each size class and from flying young of the year. Because the infants from the second size class contained the lowest body residues and the flying young contained some of the highest residue levels, the infant mortality displayed does not appear to be correlated with the pesticide residue levels found in the infants.

In 1974, infants were collected daily during the beginning of the summer and at various intervals for the remainder of the reproductive season. During the extreme dry conditions of early summer, infant mortality was very high (e.g., 661 young were collected in 24 hours compared to a maximum of 77 young in 1973). It was observed also during this dry spell that most of the adults were not flying each evening but remaining in the roost area. Thus, the high infant mortality may be related to their mothers not feeding every night and thus having low milk supplies and/or being under certain stresses and abandoning their young. To test this hypothesis, we will compare the percent of fallen young with milk in their stomachs from both years. Explaining this year's infant mortality will be very informative since the other die-offs at Carlsbad Caverns have occurred during the other drought years.

# # #

CAVE INVENTORY, PROTECTION, AND USE (ROCK STRESS STUDIES)
CACA-N-0009

INVESTIGATOR:
John S. McLean
U. S. Geological Survey

SUMMARY OF PROGRESS: Displacement transducers installed on a near-vertical joint in the lunchroom in Carlsbad Caverns measured small movements along the joint with a resolution of 3.7×10^{-6} inches (9.4×10^{-6} cm). During 1973 the maximum annual horizontal, vertical, and perpendicular displacement to the plane of the joint was 4.7×10^{-4} inches (1.2×10^{-3}, and 2.8×10^{-4} cm), respectively.

# # #

AIR POLLUTION FROM BIRDS NESTING IN CAVE (ADVISORY STUDY)

INVESTIGATORS: Robert T. O'Brien)
Ralph J. Raitt) New Mexico State University

SUMMARY OF PROGRESS: (1) Cave Swallows first appeared in the main cavern 8 years ago, when an estimated 20 birds were present; since then they have increased to an estimated 700 birds in 1974. (2) Historical populations at other caves, in Slaughter Canyon, may have decreased or even disappeared but their status was unknown. (3) No park employees have reported illnesses related to their work in the cavern. Investigation of the cavern environment and the swallows followed three lines: microbiology, behavior and ecology of the swallows, and esthetic effects of the swallows.

Fecal and air samples were analyzed as described in the *Manual for Clinical Microbiology*, 1970 edition. The results are consistent with the dry soil and low ambient humidity conditions characteristic of the cavern. Total bacterial counts are low, and neither fecal coliform bacteria nor *Salmonella* were detected. Fungal counts also are low and the dominant genera present were identified as *Mucor*, *Aspergillus*, and *Penicillium* all of which are common soil isolates and none are considered as human pathogens. The isolates obtained from the air samples were *Aspergillus* and *Mucor* which is consistent with the findings from the droppings. The airborne fungal count is extremely low, reflecting the still air conditions in the cavern. No attempt was made to determine whether ornithosis was present in the swallow population. However, none of the park personnel interviewed had seen any dead or obviously sick birds so it may be assumed that ornithosis is not present to any noticeable level in the swallow population.

We conclude from our results that the cave swallows do not represent a health hazard at this time.

Behavior and ecology of the swallows. The swallows were clearly present in large numbers (700 estimated) in the mouth of the cavern and its vicinity. Many active nests were present on the walls and roof of that portion of the cavern subject to natural light, although most of the nests were invisible, having been built in cavities, recesses, fissures, etc. There was constant flight of swallows into and out of the cave and over grounds and among buildings. Some were definitely carrying nesting material; others were almost certainly foraging, probably in part for food for nestlings. We paid particular attention to two sites: (1) lawns adjacent to the residence of USNPS personnel and (2) a group of sewage ponds near the eastern boundary of the park. One lawn was being watered at the time and large concentrations of swallows were gathering mud and plant material where sprinkler water had accumulated. Swallows in low numbers were obtaining water at the sewage ponds. Some mud was available on the bottom of one of the ponds which was nearly empty but we did not see any swallows attempting to gather it.

Esthetic effects. The esthetic effects of the swallows appeared to be both positive and negative. They constitute an appealing and interesting sight, and represent a species seldom seen by North Americans. On the other hand their defecation produces a pervasive, unpleasant odor and droppings occasionally fall directly onto people.

RECOMMENDATIONS: It appears that the swallows and their feces do not constitute an immediate health danger. It is certainly true, however, that they produce obnoxious effects. In the event of future increase in swallow population levels, adverse esthetic effects will become greater--perhaps intolerable--and the likelihood of a human disease problem would increase. As amelioratory measures we recommend the following: (1) continue to wash down walkways to reduce the possibility of injury to visitors and park personnel; (2) investigate the possibility of spraying the floor and lower walls of the relevant portion of the cavern with a disinfectant that would reduce the odor but not replace it with another; perhaps a chlorine compound would be suitable for this prupose; (3) alter work schedules of park personnel so that no individual need spend a large portion of any one day (or week) in the mouth of the cave; and (4) emphasize in interpretative presentations to the public the positive benefits of the swallows; their interesting behavior, their history in the park, and their relative rarity in the United States generally.

Reduction of swallow numbers is a difficult problem. Cave Swallows are still present in at least some of the caves. Thus, if experimentation at the main cavern with methods to reduce numbers proved extraordinarily effective, there would be no danger of complete extirpation of the species from the park. However, the problem is more likely to be one of devising a method with *any* effectiveness rather than one that would be overly effective.

Attacking the nests does not hold promise; they are too well protected. Poisoning probably would not be effective and would run risks to other forms of wildlife. Two remaining methods might be feasible and effective, singly or in combination. One is to trap birds with mist nets placed where they concentrate to obtain nesting material from watered spots near residences. Captured birds would probably have to be killed to prevent their return, although transplantation to caves in Slaughter Canyon might be effective. The second method would be to attempt to reduce their supply of nesting material. From our brief survey it appeared that the prime source of mud for nests was on watered lawns. If it were feasible to eliminate these lawns--perhaps replacing them by gardens of native plants and rocks--and to take special care to eliminate other sources of mud in the immediate area, we believe that drastic reductions in swallowing nesting densities might result. We put forth these two measures as possibilities to consider, realizing that either or both might be ineffective and that both would have accompanying adverse effects. More detailed study of the ecology and behavior of the swallow population should be undertaken, including attempting some trial reductions in numbers and devising better alternatives to the above.

A final recommendation is that a program of monitoring for microorganisms pathogenic to man be established. While at present there is no indication of any health hazard, the possibility does exist. Specific recommendations are (1) samples of droppings should be taken and analyzed at least once a month during the time birds are in residence; principal emphasis should be on detection of fecal coliforms, *Salmonella*, and fungi; and (2) in the event of an unusually large number of dead or sick birds, they should be collected and autopsied to check for diseases transmissable to man, such as ornithosis and mycoses.

# # #

CORRELATION OF INDICATOR PLANTS AND ARCHEOLOGICAL SITES, CHACO CANYON NATIONAL MONUMENT

INVESTIGATOR: Loren D. Potter
University of New Mexico

SUMMARY OF PROGRESS: To determine possible correlations of vegetation to archeological sites of known age, line-intercept transects are run across sites, and relief and soil type noted. Eleven sites have been examined: three of PI-III age on talus slopes; four of PII-early PIII on mesa tops; one at PI site on a talus ridge in the valley; two at BM-3 sites on talus ridges; and one BM-3 site on the valley floor.

TENTATIVE CONCLUSIONS: (1) Descurainia, an indicator of disturbed, clayey soils, when growing on slopes or the tops of small rises seems to indicate the presence of a buried, or partially buried, ruin. This is probably due to an increase of clay from weathered mortar.

(2) One instance was found of *Sarcobatus* growing in an unusual location on a mound near the base of Fajada Butte over what later proved to be a room of a pueblo. Because of its usual correlation with heavy clay, alkaline, or saline soils with available ground water, it is hypothesized that the ruins may have provided a catchment basin with a compressed, impervious clay floor.

(3) *Lycium* seems to be favored by clayey soils and was found to be locally present at Penasco Blanco, Pueblo Alto, and two other sites. Ed Kelley, who started the field work, suspected this might be useful as a BM-3 indicator. More observations are necessary.

(4) *Eurotia*, typical of heavy soils, is sometimes in great abundance on the slopes of mounds over pueblo ruins and was common at sites 3, 4, 5, 6, 7, 8, 9, and 11.

It is planned to examine PI and BM-3 sites on the mesa top and two late PII-early PIII sites on the valley floor.

Known historic influences, e.g., dikes, ditches, roads, land treatments, will be transferred to the now available vegetational base map and comparisons made of the vegetation with surrounding areas.

Transect data still needs to be analyzed.

An extension of time from 1 February to 1 August 1975 has been requested because of the necessity of change in personnel from Ed Kelley to Richard Young who was not able to devote full time to the project and because of the severe drought of the summer of 1974 and the resulting paucity of vegetative growth.

# # #

ECOLOGICAL SURVEY OF CHACO CANYON AREA

INVESTIGATORS:	Loren D. Potter) University of New Mexico Ed Kelley)
SUMMARY OF PROGRESS:	The final report was submitted in May 1974, including the work on mammals and herptiles and a description of the vegetation of Chaco Canyon, plus a vegetative type map of Chaco Canyon.

# # #

TOPOGRAPHIC MAPPING OF CHACO CANYON NATIONAL MONUMENT PUEBLO SITES

CHCA-7480-N-2500

INVESTIGATOR: Koogle & Pouls Engineering, Inc.
Albuquerque, New Mexico

SUMMARY OF PROGRESS: The services required under this contract include detailed topographic and planimetric mapping for eight pueblo sites and the development of wall sections for two pueblo sites utilizing terrestrial photography with all ten sites located in the Chaco Canyon National Monument. In addition, terrain digitizing will be developed at the Penasco Blanco Pueblo Site.

The services completed through 31 December 1974, include the completion of the construction for a camera mount and the obtaining of terrestrial photography utilizing a helicopter for the project site of Talus House near the pueblo site of Chettro Kettle. In addition, the topographic mapping was commenced for the remaining six pueblo sites.

# # #

HYDROLOGY OF CHACO CANYON NATIONAL MONUMENT AREA

INVESTIGATOR: Garland Moore
National Park Service

SUMMARY OF PROGRESS: There has been no significant progress since last year's annual report.

# # #

CHALMETTE NATIONAL HISTORICAL PARK

CHEMICAL GRASS RETARDANTS

INVESTIGATOR: G. S. Rai
Southern University, New Orleans

SUMMARY OF PROGRESS: The use of plant growth regulators, which includes retardants, in modifying the plant processes in some horticultural crops has led to their commercial application. This approach is based upon the theory of "apical dominance." The underlying idea being that the terminal bud of a stem produces a form of definite substance(s) which is antagonistic to lateral bud growth as it travels down in a strictly polar manner, that is, only from the morphological tip to the morphological base.

Frequent mowing of grasses, however, does away with this effect of apical dominance as the apical growing points are clipped, thereby causing stimulation of lateral buds and tillering. Grass growth soon becomes unmanageable, particularly during spring and summer months, on account of the development of lateral buds into new shoots and the emergence of adventitious roots on grass runners at each node.

To avoid problems associated with mowing, expensive labor, and energy needs of mowers besides their wear and tear, plant physiologists and agronomists have sought to employ the use of chemicals as foliar sprays or otherwise as alternative measures. Consequently, an exhaustive search led to the use of four chemicals:

Common Name	Supplied By
1. Maleic hydrazide	Uniroyal
2. Maleic hydrazide	Ansul
3. Maintain CF125	U.S. Borax
4. Sustar 2S	Velsicol

On 8-11 October 1974, these chemicals were sprayed in solution concentrations of: (1) 5,000 ppm; (2) 10,000 ppm; (3) 20,000 ppm, on grass plots (15.0 X 25.0 ft) having an area of 375.0 ft^2. The plots were arranged according to Latin square system.

From the first grass mowing operation the fresh weight[1] indicated the trend favoring the use of chemical retardants. However, the concentration differences were erratic for Maintain and Sustar, indicating high concentrations of 20,000 ppm to be favoring growth rather than suppression. On the other hand, maleic hydrazide from Ansul consistently suppressed growth.

Further tests are needed for any conclusive results.

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[1] Plot size 10.0 X 20.0 = 200.0 sq. ft.

# # #

CRATER LAKE NATIONAL PARK

BLACK BEAR STUDY

CRLA-N-002A

INVESTIGATORS: Michael McCollum)
James A. Blaisdell) National Park Service

SUMMARY OF PROGRESS: Our final report was submitted 20 January 1974. Findings indicate that with closure of dumps, a rigorous program of transplanting, and tame-bear control, must be undertaken. Without bear-proofing the entire park, controls are not the answer. Recommendations for future management are given (bear-proofing areas) in our report. Bear problems decreased significantly after strict controls in 1972.

# # #

VEGETATION DYNAMICS IN PONDEROSA PINE FOREST, CRATER LAKE NATIONAL PARK

CRLA-N-13

INVESTIGATORS: Robert C. McNeil)
Donald B. Zobel) Oregon State University, Corvallis

SUMMARY OF PROGRESS: We have completed all phases of field work. Data analysis of age-size data and fire-scars collected and formulation of recommendations have yet to be completed.

The plant communities present have been mapped and identified; their relationship to parent material and, in some cases, to moisture stress has been determined. The presence of pumice flow material leads to development of different communities than that of allumium, apparently through an effect on soil moisture availability; saplings on pumice have lower moisture stresses than on allumium. Communities are also distinguished by their past history and stage of succession, as well as their place in an environmental gradient running from low to higher elevations. Four habitat types including *Abies concolor* are distinguished by understory species and form the lower elevation vegetation. Highest elevations have an *A. magnifica* var. *shastensis* habitat type. Two other types occur on very dry and very moist habitats.

From data collected, the age distribution of the forest will be estimated, and the frequency of fires in various areas of the forest can be estimated from cross-sections of fire scars collected.

The possibilities and limitations of using controlled fire for vegetation management on the area were discussed with three fire experts from the U.S. Forest Service during a trip through the area.

The time schedule and proposed work to be completed should be approximately as originally proposed.

# # #

BALSAM WOOLLY APHID TREND STUDY
CRLA-N-11

INVESTIGATOR: Russel G. Mitchell
U.S. Forest Service

SUMMARY OF PROGRESS: Some 200 subalpine fir trees were inspected on two plots. For the first time in several years, no trees had detectable populations of the balsam woolly aphid. Nine trees have died since the last evaluation in 1972. Most of them died in 1973. Many trees that were severely damaged in the past are showing recovery. It appears, though, that a few of the most seriously damaged trees will continue to decline and eventually die.

A check on cone production showed a pattern of good cone crops every 3 years on subalpine and Shasta (noble?) fir. Large cone crops were recorded in the years 1965, 1968, 1971, and 1974.

# # #

NATIONAL NETWORK OF HYDROLOGIC BENCHMARKS
CRLA-N-0006

INVESTIGATOR: U.S. Geological Survey
Water Resources Division

SUMMARY OF PROGRESS: We are continuing to collect samples of lake water and make chemical quality analyses periodically (about 3 or 4 times per year) and collecting daily maximum and minimum water temperatures. All of this is under the Hydrologic Benchmark program.

# # #

ELK, THEIR ECOLOGY AND MANAGEMENT
CRLA-N-15A

INVESTIGATOR: Roy L. Manning

SUMMARY OF PROGRESS: The main progress has been to determine the major elk concentration areas in the park. The two major areas of elk concentration are Union Peak and Crater Peak.

A minimum elk population of 161 elk is estimated for the park, and a cow:calf ratio for 1974 determined as 31 calves per 100 cows with a 3 year average--1970, 1973, and 1974--as 35 calves per 100 cows.

The principal range for elk is among lodgepole pines where small openings provide ample elk forage. Range condition is good on all elk habitable areas, but problems due to overgrazing by elk could develop around Union Peak. Signs of heavy grazing are evident around Union Peak in late August.

RECOMMENDATIONS: The study should be continued through the 1975 season with the same objectives. A capture technique and a radio tagging operation of elk would be very helpful in gathering data, especially data relating to migration. Aerial observations should also be used to help determine location and number of elk in the park.

# # #

PUMICE DESERT ECOLOGY STUDY--FOLLOW-UP
CRLA-N-005A

INVESTIGATOR: Elizabeth L. Horn

SUMMARY OF PROGRESS: The last analysis was done in 1965. Work during the summer of 1975 will reevaluate contents of the sample plots that were permanently marked in 1965.

# # #

SMALL MAMMAL DISEASE SURVEY
CRLA-N-0008

INVESTIGATOR: Robert A. Gresbrink
Oregon State Health Division

SUMMARY OF PROGRESS: The small mammal disease survey is conducted biennially (in the case of animal die-offs, investigations as required) on a routine basis.

No survey was conducted in 1974 and the next is due in 1975.

RECOMMENDATIONS: We recommend that the surveys be continued at the present level.

# # #

BLACK BEAR STUDY AND MANAGEMENT IMPLICATIONS
CRLA-N-2A

INVESTIGATORS: Michael T. McCollum
James A. Blaisdell

OBJECTIVES: Management recommendations based upon black-bear studies dating back to 1944 (Dixon) and 1969 (Herrero) include as the first step the closure of all garbage dumps in the park. These recommendations were to be started during the winter of 1971-72 and continued. Scope of the study includes those listed for the original RSP-CRLA-N-2: "To determine the habits, population, longevity, reproduction and other pertinent ecological characteristics of the black bear in and near the park, the results to be used in the management (including the bear problem) and interpretation of this species for the park."

1. Determine the reactions of bears to the closure of all garbage dumps in the park.
2. Obtain an estimate of total bear numbers in the park.
3. Determine which bears are nuisance or dangerous bears.
4. Provide information on numbers of park bears which may be harvested by hunters on adjacent lands, and the effects of hunting on park bear populations.

The study is meant to show primarily the changes in bear feeding habits and tendencies toward property damage and personal injuries because of dump closures. Studies of this type have been accomplished previously in several parks but in this case all dumps are to be closed at one time and permanently. This may or may not change the bears' habits.

METHODS: During 1972, McCollum concentrated on nuisance bears, nearly all from the residence of village area. Bears were moved out of the park and their movements traced. In 1973 the work shifted to wild bears, those not affected by improper garbage disposal practices.

RESULTS AND DISCUSSION: With the submission of McCollum's final report, Research and Management of Black Bears in Crater Lake National Park, Oregon, January 20, 1974, this project may be considered complete.

The areas heavily utilized by visitors and residents have had few nuisance bear problems since most of the garbage-eating bears were moved out in 1972. The dumps remain closed although a few garbage disposal methods (non-bearproof cans) continue. In 1973 McCollum's tagging and telemetry work indicated a wild population of approximately 100 bears. There is some indication that the park bear population supplies hunting where home ranges overlap the park boundary. McCullom did not feel, however, that hunting on Forest Service lands adjacent to the park affected park populations. Hunting pressure is low, however. No bear diseases were discovered, nor were external parasites observed.

CONCLUSIONS: Crater Lake National Park supports a healthy black bear population. Bear incidents are presently nearly non-existent because of the control of nuisance bears and efforts to eliminate the sources of garbage. Copies of McCollum's final report are in the Pacific Northwest Regional Office.

# # #

ELK, THEIR ECOLOGY AND MANAGEMENT

CRLA-N-15

INVESTIGATORS: Roy L. Manning
James A. Blaisdell

OBJECTIVES: Elk occur in sections of the park during the warmer seasons of the year. Little is known of the total population, distribution, migration routes and dates, and other information necessary for proper interpretation and management both within and outside the park. Henley (CRLA-N-15) reported on his activities during an elk survey 15-19 July 1970. He presented no estimate of total population or total range and range condition. It was proposed that with cooperating agencies (Oregon Game Commission and U.S. Forest Service) we determine the following:

1. Sub-species of elk inhabiting the park.
2. Population, reproduction, and survival of elk.
3. Migration directions and seasons.
4. Principal range and condition.
5. Management occurring and needed.
6. Possible interpretive data.

The purpose of the project is to determine the many unknown factors regarding elk in Crater Lake National Park.

Total expenditures of time and funds for this study remain low although more effort has been put forth this year than last.

METHODS: All research carried out has been via the recon method, with numbers and locations of animals being recorded as well as range utilization being observed. Most of the park has now been walked over, and elk numbers estimated.

RESULTS AND DISCUSSION: Manning spent the major part of the summer attempting to obtain sightings and track counts of elk in the park. Two areas proved to have fairly dense populations of elk: the southwest corner (Union Peak) and the southern area (Crater Peak, Sun Creek). Elk are found in all areas not too heavily used by people, however. A total of 161 elk was estimated, and this is felt to be minimum. Two large groups were observed by park visitors--one group of 50-75 and another of 54. Herd composition is very difficult to ascertain when so few groups are classified, but from very scattered observations, we can report calf:cow ratios as follows: 1970, 30:100; 1973, 41:100; 1974, 35:100.

A late season last spring (snow still in the wilderness areas in August) precluded the entrance of elk into some sections of the park until September. Thus, we feel our counts were low in 1974.

Foods consumed by elk include:
Presley sedge (*Carex preslii*)
Dirty socks (*Eriogonom pyrolaefolium*)
Anderson lupine (*Lupinum andersonii*)
Newberry knotweed (*Polygonum newberryi*)
Bracken fern (*Pteridium aquilinum*)
Sedge (*Carex* spp.)
Willow (*Salix* spp.)
Chinquapin (*Castonopsis chrysophylla*)
Pumice sandwort (*Arenaria pumicola*)
Western needlegrass (*Stipa occidentalis*)
Umbellate pussypaws (*Spraguea umbellata*)
Bluegrass (*Poa* spp.)
Squirreltail (*Sitanion hystrix*)
Smooth woodrush (*Luzula glabrata*)
Rush (*Juncus* spp.)
Blue wildrye or western rye-grass (*Elymus glaucus*)

Lyall lupine (*Lupinus lyallii*)
Mountain brome (*Bromus carinatus*)

The flats around Union Peak are the only park lands illustrating heavy use of these plants, but use is probably not heavy enough to sustain permanent damage. Care should be taken in the future, however, to observe this area for overutilization. Also, in some areas, firs and mountain hemlocks are shading out browse and graze plants. They are also invading some flats now used by elk for feeding. At some time in the future, a study should be initiated to determine the need and feasibility of natural forest clearing for elk management.

CONCLUSIONS: Some important data have been collected during the past 3 years. Interpretation most certainly has been made easier. This should be a continuing project for the collection of data for submission to the Forest Service and the Oregon Wildlife Commission.

PLANS FOR 1975: Continue studies as funds and manpower allow.

# # #

CUMBERLAND GAP NATIONAL HISTORICAL PARK

NATURAL HISTORY RESEARCH PROJECT

INVESTIGATOR: Ross Hinkle
University of Tennessee, Knoxville

SUMMARY OF PROGRESS: This project's objectives are to determine the vegetation types and flora of the forested portion of the Cumberland Gap National Historical Park; from information available, we will also determine past land care. The data collected can be applied to the determination of an environmental setting similar to that of the Gap area during the Daniel Boone era and to aid in the relocation of old Wilderness Road.

Field data collection has included special trips to various parts of the park and a summer's work in the forested area itself. So far 490 plant taxa (ca 950 specimens) have been determined. One hundred sixty-six 0.1 acre plots were used to assess vegetation character. Present work includes determination of the most difficult flora, compilation and analysis of plot data, and collection of aerial imagery to be used toward the construction of a past land use map.

# # #

SURVEY AND STUDY OF EXOTIC PLANTS
CUGA-N-3

INVESTIGATOR: J. Kermit Bailey
Lincoln Memorial University, Harrogate, Tennessee

SUMMARY OF PROGRESS: The above research project was not continued during the summer of 1974 because we did not have enough qualified workers or adequate funds.

# # #

ECOLOGICAL STUDY OF BAILES MEADOWS
CUGA-N-5

INVESTIGATOR: J. Kermit Bailey
Lincoln Memorial University, Harrogate, Tennessee

SUMMARY OF PROGRESS: The above research project was not continued during the summer of 1974 because we did not have enough qualified workers or adequate funds.

# # #

DEATH VALLEY NATIONAL MONUMENT

DESERT HOLLY
DEVA-N-05

INVESTIGATOR: Ernest E. Banttari
University of Minnesota

SUMMARY OF PROGRESS: (1) Our survey and collection of specimens were made at the following sites:

Sites 1 and 2. The vicinity west of the junction of Highway 190 and the road to Beatty and WNW of H 190 and Salt Creek Road. Both of these areas are at or near the floor of the valley.

Site 3. An area ENE of the junction of the roads to Beatty and Keane's Wonder Mine.

Site 4. Areas on both sides of the road to Beatty, 1.5 m SSW of Hell's Gate.

Site 5. Area WNW of Hell's Gate.

Site 6. Up to 3 m NW of Hell's Gate along road to Beatty.

(2) Die-back symptoms are evident on several kinds of desert plants, including desert holly, creosote bush, burro bush, as well as other unidentified species. It appears that desert holly has been degenerating for a long time as evidenced by abundant "skeletons" at all elevations and sites. Recent decline of desert holly is most apparent beginning from the area at the junction of the roads to Beatty and Keane's Wonder Mine, progressing NNE to Hell's Gate and up to about 3 m NNW of Hell's Gate (elevation about 3000 ft). The problem is not apparent, or at least as severe, at lower elevations (elevation below 500 ft) and at the valley floor, at least west of Highway 190 in the vicinity of the junction of the road to Beatty and Salt Creek Road.

(3) Plants along roadway right-of-ways appear in better shape than those away from roadsides. Leaves are succulent; foliage and plants with stems even over one inch in diameter and up to 3 ft tall have a light gray-green color, and the plants appear vigorous. Even though the average annual precipitation is only slightly over 1.5 inches, it is possible that highway run-off provides slightly more water for plants on the road shoulder and promotes better growth. This confirms observations by N. A. Anderson and F. A. Wood.

(4) Plants with stems 0.75 inch diameter or larger at the base that have decline symptoms or have affected branches frequently have signs of invasion by the flat-headed wood borer. N. A. Anderson also reported this. We found some plants, usually older ones, that had borer holes but had no decline symptoms.

(5) Plants affected with decline were prevalent in an area ENE of the junction of the roads to Beatty and Keane's Wonder Mine (elevation about 1000 ft). Plants as small as 6-8 inches with base stem diameters 0.5 inch or less were affected. Some plants were completely defoliated; on others the leaves were brittle and dropped when the plants were touched. There were no signs of insect injury. Some cause, yet undiscovered, such as pollution, virus, drought, a poor site, or a root pathogen could be responsible.

(6) Several kinds of galls are prevalent on desert holly on both sides of the road to Beatty 1.5 m SSW of Hell's Gate (elevation about 1500 ft) and up to about 3 m NNE of Hell's Gate (elevation 3000 ft). The galls appeared to be caused by an insect; however, most had matured and were empty. A few contained larvae; however, identification may be difficult unless adults could be trapped. Plants or some branches of otherwise clean plants that are heavily infested with galls were defoliated and appeared to be declining. Any sized plant may be affected, and no signs of flat headed borer attack were evident on stems less than 0.5 inch diameter at the base.

We think the galls are capable of severely weakening if not killing desert holly. Weakened plants or branches of plants over 0.75 inch diameter may subsequently be invaded by the flat headed borer and *Fusarium* as described by N. A. Anderson. The gall insects have now been identified as *Ceccidoymid* sp.

(7) We collected samples of affected as well as healthy-appearing desert holly, placed them in plastic bags, and kept them in an ice chest until we returned to St. Paul. Mechanical inoculations were made to a series of virus indicator hosts; however, none have developed symptoms of virus infection as of this date. They will be observed for another 2-3 weeks.

Samples were processed for leaf-dip electron microscopy and tissues were also fixed and embedded for histological examination. This is necessary to detect mycoplasma-like organisms or may help to show if a non-mechanically transmitted virus is present. These studies are not yet completed.

Less attention was given to creosote bush, but samples of several bushes affected with die-back, as well as healthy-appearing plants were collected for histological examination, leaf-dip electron microscopy, and inoculation to indicator hosts. The results of these studies are not yet available. Flat headed wood borer invasion of larger stems of affected bushes was observed.

(9) Dried dodder was observed on burro bush and on other plants. A few plants were heavily infested. Dodder appeared not involved in die-back of desert holly or creosote bush.

# # #

BIGHORN ECOLOGY
DEVA-N-10

INVESTIGATOR: Charles L. Douglas

SUMMARY OF PROGRESS: This is a continuing project that probably should not be terminated in its entirety.

Various spring areas have been visited during the past year, and considerable time has been spent becoming familiar with bighorn habitats in the Death Valley area.

Observer counts in 1973 indicated a good lamb survival by late August. This encouraging sign was reflected in a reasonably good yearling count in late August of 1974. Time-lapse cameras were placed at five of the more productive springs at which observers counted bighorn sheep during the 1974 count. The camera counts tallied quite well with the observer counts but more work is needed before we can determine the precise correlation between the two methods. At present, films are being examined for determination of age groupings of bighorn. This is done by means of a dissecting microscope, since projection of the film does not allow precise aging.

Cameras will be placed on springs in the same mountain ranges (rather than in a haphazard sampling throughout the monument) in the summer of 1975. Additional study will be made of available water sources and utilization of these water sources by burros and bighorn.

Plans to begin a study of comparative food habits of bighorn sheep and burros have been delayed owing to budget cuts for FY75.

# # #

HYDROLOGICAL SURVEY OF DEATH VALLEY

DEVA-N-13

INVESTIGATOR: Glen A. Miller
U. S. Geological Service

SUMMARY OF PROGRESS: A final report is in preparation and will receive a technical review early in 1975.

# # #

SALINITY TOLERANCE & BLOOD PROPERTIES OF PUPFISHES

INVESTIGATOR: Robert Naiman

SUMMARY OF PROGRESS: Salinity tolerance, plasma osmolarity, and percentage of blood plasma, were examined in *Cyprinodon milleri* at salinities ranging from fresh water to 3.5 times concentration of sea water. Plasma percentage ranges between 56% and 65% for all test salinities. This pupfish tolerates large changes in plasma osmolarity while being a partial osmoregulator throughout a wide range of ionic concentrations. The upper lethal salinity (LC_{50}), determined from 96 hr experiments, is 88% and the upper limit of plasma osmolarity is about 507 m-osM/l.

Work may be expanded in the future. Our laboratory techniques are good but we need more detailed data at higher salinities (>80%).

Publication

Naiman, R. J., S. D. Gerking and R. E. Stuart. 1974. Salinity tolerance of a euryhaline Death Valley pupfish (*Cyprinodon milleri*). To be submitted to *J. Comp. Physiol.* within a few weeks.

# # #

A BIOSYSTEMATIC STUDY OF ANNUAL SPECIES OF *CALYPTRIDIUM* (PORTULACACEAE)

INVESTIGATOR: John M. Miller
Oregon State University

SUMMARY OF PROGRESS: This project was terminated 31 March 1974. A preliminary herbarium study was completed 20 March 1974. *Calyptridium* displays little morphological variability *within* each taxonomic category however, variation is evident between taxonomic species. All published chromosome counts indicate the lack of polyploidy (all counts are 2n=44).

RECOMMENDATIONS: I have reoriented my research efforts towards another member of the Portulacaceae, *Montia perfoliata* (Donn) Howell. Any further work on *Calyptridium* should be biochemically oriented (e.g., flavonoid or isoenzyme studies). No further work is planned on the genus *Calyptridium* by this researcher.

The Superintendent of Death Valley National Monument was very helpful in granting the collection permit request. His efforts are greatly appreciated.

Recommendations for the protection of *Calyptridium:* Certain rare members of this genus (in particular *C. parryi*) are found in the region of Mahogany Flat and "Thorndykes" according to my herbarium studies. If these plants are still found in these areas, they should be protected from human abuse.

# # #

ECOLOGY OF DESERT ANNUALS

INVESTIGATOR: Fritz Went

SUMMARY OF PROGRESS: Observations on germination and survival of seedlings was continued in 1974.

# # #

FEEDING HABITS OF DESERT ANTS

DEVA-N-1

INVESTIGATORS: Steven W. Rissing, Univeristy of Washington, Seattle
George C. Wheeler)
Jeanette Wheeler) Desert Research Institute

SUMMARY OF PROGRESS: So far we have published one paper: Feeding and digestion in some ants (*Veromessor* and *Manica*). 1972. *BioScience* 22:82-88, with Frits Went. We have a paper in press: Wheeler, J. and S. W. Rissing. The natural history of *Veromessor pergandei*. *Pan-Pac. Entomol.* We have a third paper in preparation: Rissing, S. W., and J. Wheeler. Foraging responses of *Veromessor pergandei* to changes in seed production.

We hope to continue, as long as we are permitted, to study the nest on the grid near Grapevine Ranger Station and the nests near the Laboratory of Desert Biology trailer site. We have just started studying various factors in the colony life of this one species.

Every answer we get raises more problems.

# # #

METAMORPHISM IN THE DEATH VALLEY REGION

INVESTIGATOR: Theodore C. Labotka
California Institute of Technology

SUMMARY OF PROGRESS: Sampling and mapping in the Panamint Mountains (Telescope Peak Quadrangle primarily) are largely completed. I am currently sampling in the Funeral Mountains (Chloride Cliff Quadrangle), and I expect to finish most of the collecting this winter.

The Precambrian and Cambrian (?) rocks in the Panamint Mountains have been metamorphosed under low pressure conditions during the Cretaceous Period. The intensity of metamorphism is greatest along the western margin of the range between Happy and Wildrose canyons. Mineral assemblages in the pelitic rocks include chloritoid-staurolite-biotite, andalusite-staurolite-biotite, andalusite-cordierite-biotite, and cordierite chlorite-biotite; all also contain muscovite and quartz. Assemblages in carbonate rocks include combinations of quartz, calcite, dolomite, talc, and tremolite. Diopside appears in the highest grade areas. Amphibolites also occur throughout the Panamint Mountains, and I hope to use assemblage and compositional data of these rocks to define more carefully the degree of metamorphism.

The rocks of similar age in the Funeral Mountains are also metamorphosed, but the mineral assemblages in the pelitic rocks indicate that the metamorphism occurred at somewhat higher pressure than that of the Panamint Mountains. There is no incontrovertible evidence to suggest that the metamorphism of the two areas occurred simultaneously. Indeed, the differing pressure regimes of the two areas point to two separate and distinct events. The rocks from the Funeral Mountains are now being studied to document the mineral assemblages and their relation to the pressure of metamorphism, to determine if two or more episodes of metamorphism have affected the Funeral Mountains, and to provide a link between the metamorphic terrain in the Panamints to the terrain in the Funerals with respect to space and time.

# # #

ENDOLITHIC ALGAE

INVESTIGATOR: E. I. Friedmann
Florida State University

SUMMARY OF PROGRESS: Results on standing crop of endolithic algae in Death Valley will be published soon. Living material at present maintained in my laboratory may be used in the future for further studies.

# # #

GEOLOGY OF A PART OF THE UBEHEBE CRATER QUADRANGLE, NORTHERN DEATH VALLEY, CALIFORNIA

INVESTIGATOR: Edward Oakes
University of Wyoming

SUMMARY OF PROGRESS: Stratigraphic and structural features of an undifferentiated Paleozoic sequence, approximately 5 miles northwest of Scottys' Castle, will be mapped in detail. This mapping may help determine the magnitude of displacement along the Death Valley-Furnace Creek fault zone which trends northwesterly along the southwest side of the Grapevine Mountains. Finally, the geologic history of northern Death Valley will be outlined.

# # #

LICHEN FLORA OF DEATH VALLEY

INVESTIGATOR: J. Elliot Weier
University of California, Davis

SUMMARY OF PROGRESS: We were unable to make a collecting trip to Death Valley in February 1974 as planned. We hope to spend the week of 8 January to 15 January 1975 collecting lichens in Death Valley.

# # #

SILURIAN CONODONTS

INVESTIGATORS: Richard H. Miller) San Fernando Valley State College
Frank M. Hanna)

SUMMARY OF PROGRESS: Original project on Silurian conodonts (microfossils). Field work complete and dissertation submitted to UCLA, fall 1974.

Based on original work, conodonts were discovered in Cambrian, Ordovician, and Devonian rocks. Analysis of these faunas is continuing in a number of separate projects and will involve a number of years for completion.

Publications

Silurian conodonts from Death Valley California (abstract). 1973. Am. Assoc. Pet. Geol. Annu. Meeting.

Silurian conodonts from Death Valley: Preliminary Report. 1972. *J. Paleontol.* 46:922-924.

Revision of Late Ordovician, Silurian, and Early Devonian Stratigraphy; southwestern Great Basin (in press). *Geol. Soc. Am. Bull.*

Silurian conodont biostratigraphy of the southwestern Great Basin. 1975. Dissertation. UCLA.

# # #

PHYSIOLOGY OF MAN IN EXTREME HEAT

INVESTIGATOR: David B. Dill
Desert Research Institute, University of Nevada

SUMMARY OF PROGRESS: We continued desert studies in Boulder City in the summer of 1974. We hope to spend a few days in Death Valley in the summer of 1975.

# # #

ARCHEOCYATHID FAUNAS OF THE LOWER CAMBRIAN

INVESTIGATOR: Roland A. Gangloff
University of California, Berkeley

SUMMARY OF PROGRESS: I am presently finishing the first draft of my dissertation. It will be submitted to my committee members for critique in December 1974.

The Archeocyatha of the Death Valley lithofacies are greatly restricted spatially and temporally. The assemblages are impoverished in respect to diversity. The Archeocyatha definitely back up correlations made on trilobites which recognize the upper limestone members of the Wood Canyon formation as being closely equivalent to the Poleta Limestone (lower member) of the White-Inyo facies. To date, only three taxa are recognized from the collections made at Echo Canyon and Daylight Pass. There are *Diplocyathus vulgarus* n. sp., *Diocyathus stewarti* n. gen. et n. sp. and *Pycnoidocyathus* sp. The first one listed is cospecific with specimens collected from the Poleta Formation at Magruder Mountain and Silver Peak, Nevada, as well as from the Gold Hill formation at Ravenswood, Nevada, in the Shoshone Range.

# # #

RADAR IMAGERY OF DEATH VALLEY

INVESTIGATORS: Graydon L. Berlin)
Gerald G. Schaber) U. S. Geological Service

SUMMARY OF PROGRESS: G. L. Berlin and G. G. Schaber have spent approximately 1.5 months in Death Valley during the past 4 years, field evaluating 25 cm wavelength airborne side-looking radar (SLAR) images obtained by Jet Propulsion Laboratory personnel in 1969 and 1970. These overflights served as calibration tests for a prototype radar system designed to obtain high resolution image and profile data from orbit around the cloud-covered planet Venus. The Death Valley region was selected as a calibration site due to the nearly total lack of flowering vegetation on the valley floor and the extremely low yearly precipitation rate.

The radar images of the salt flats and alluvial fans show distinctive variations in backscatter (image gray tones) that can be correlated with systematic changes in surface roughness of differing geologic units. Well-developed desert pavements on the oldest of the late Pleistocene boulder gravels are clearly delineated as specular reflectors on the imagery. Distinct low backscatter bands (not differentiated on published geologic maps) along the base of all alluvial fans were found to be caused by loose sandy facies with reduced gravel and cobble populations. Flood-plain deposits are characterized by very low backscatter because of minimal surface roughness. Massive rock salt returned the strongest echo of any geologic unit because of a favorable surface geometry.

The large range of differences in surface roughness permitted a detailed investigation of the transition point at which the height of surface irregularities produces a change from diffuse to specular backscatter. This transition point is restricted to a smaller size range than heretofore believed. Antenna depression angles of 45°-90° appear to be best suited for investigations of surface roughness with long-wavelength (25 cm) radar systems.

Segments of this research will be published in the following forms:

> Special applications of SLAR image data for signature analysis. *In* Proceedings, NASA Active Microwave Workshop, Texas A&M University.
>
> Surface roughness variations within Death Valley, California: Geologic Evaluation of 25 cm Wavelength Radar Images. *Bull. Geol. Soc. Am.* In review.

The current phase of the project is centering on a multispectral analysis of the saline units comprising Cottonball Basin and the sand dune area near Stovepipe Wells. Data sets include: 25 cm Jet Propulsion Laboratory radar imagery, 3 cm Goodyear Aerospace radar imagery, Earth Resources Technology Satellite (ERTS-1) imagery, including computer simulated "true" color, and Skylab multispectral (6 band) photography. Field work is expected to be completed by June 1975, and manuscripts will hopefully be in review stages by mid-1975.

# # #

PRECAMBRIAN SEDIMENTARY ENVIRONMENTS OF DEATH VALLEY REGION

INVESTIGATOR: Lauren A. Wright
Pennsylvania State University

SUMMARY OF PROGRESS: See papers in Guidebook to the Geology of Death Valley GSA Cordilleran Section 1973. Time schedule and support level should proceed as planned. Detailed study of Crystal Spring Formation complete; detailed study of Word Canyon Formation will be completed in June 1975; detailed study of Stirling Quartzite started in December 1974; and detailed study of Kingston Peak Formation continues.

# # #

GEOLOGY OF N. ½ CONFIDENCE HILLS QUADRANGLE

INVESTIGATORS: Lauren A. Wright, Pennsylvania State University
Bennie W. Troxel, Geological Society of America

SUMMARY OF PROGRESS: Mapping has been completed for 2 years. Map will be published as map sheet of Calif. Div. of Mines and Geology and will also accompany a special paper of the Geol. Soc. Am. Map should be submitted to the printer within the year. No changes suggested.

# # #

LEPIDOPTERA STUDIES

DEVA-N-I

INVESTIGATOR: James F. Wells
Los Angeles Museum of Natural History

SUMMARY OF PROGRESS: To date all work is on the emphasis of species within park boundaries. Areas of concentration are (1) Daylight Pass, (2) Telescope Peak/Mahogany Flats, and (3) Wildrose Canyon.

There are 15 species within the above areas representing 7 families.

To completely cover the park for additional species and determine the range that each specie covers will take about 5 years. Due to a very restricted collecting period (February to about June) caused by severe heat and rough terrain this possibly is a conservative time estimate. In addition, those species that are cyclic (appearing every 3rd or 5th year) due to weather factors are unknown. Larval stages--food plants--parasitic insects and many additional factors are yet to be discovered. Frankly I am amazed at the number of species I have collected in such a short period of time. For example, it was known by Dr. John Emmel of Los Angeles that *Papilio indra martini* was prevalent in the areas north of the pass in Inyo County and to the southeast in the Providence Mountains of San Bernidino County. My capturing 4 specimens from Telescope Peak and Mahogany flats area add a new dimension to this unique species. Further investigation should be allowed as there are possibly many more exciting discoveries to be made.

# # #

MOVING ROCKS ON RACETRACK PLAYA

DEVA-N-I

INVESTIGATOR: Robert P. Sharp

SUMMARY OF PROGRESS: Preliminary manuscript sumbitted.

# # #

GEOLOGY OF CHLORIDE CLIFF & BIG DUNE QUADRANGLES

INVESTIGATORS: Lauren A. Wright, Pennsylvania State University
Bennie W. Troxel, Geological Society of America

SUMMARY OF PROGRESS: Mapping essentially completed in 1970. We will review in the field January-February 1974. The map should be submitted to draftsmen in 1975. The report will be started in 1975. No changes in project suggested.

# # #

GEOLOGY OF NW¼ SHOSHONE QUADRANGLE

INVESTIGATOR:	Lauren A. Wright Pennsylvania State University
SUMMARY OF PROGRESS:	Mapping will be completed in January-February 1975. The maps should be submitted to draftsman in 1976. No changes suggested.

# # #

THE GEOLOGY OF THE SALT SPRINGS AREA AND ITS BEARING ON LARGE-SCALE MESOZOIC STRUCTURES IN SOUTHEASTERN CALIFORNIA

INVESTIGATOR:	Richard G. Randall San Jose State University
SUMMARY OF PROGRESS:	Field research in Death Valley National Monument was completed in May 1974. The following summary is an abstract from my M.S. thesis, which is nearing completion and has the title shown above.

The Salt Springs area, located at the east foot of Tucki Mountain in Death Valley National Monument, is the only place in the southern Panamint Range north of Butte Valley where rocks of Mississippian age are exposed. It appears likely that facies relationships in Mississippian rocks may be useful in determining the magnitude and extent of Early Mesozoic thrust faulting in this portion of southeastern California. Earlier workers have recognized several important Early Mesozoic thrust faults in the region between Death Valley and Owens Valley; these include the Inyo, Last Chance, Racetrack, Marble Canyon, Lemoigne, and Layton Well thrust faults. Another large thrust fault may be present at Butte Valley in the southern Panamint Range, but the actual fault contact apparently is not exposed, being intruded everywhere by granite or concealed by alluvium. Previous research has shown that Mississippian rocks exposed in Warm Spring Canyon, part of the proposed lower plate of the Butte Valley thrust fault, are strikingly different from those exposed in the upper plate near Salt Springs, indicating that a large amount of movement may have occurred on the Butte Valley thrust fault.

Results of the present study in the Salt Springs area confirm the presence there of the Late Mississippian Rest Spring Shale, a formation which is not present in Warm Spring Canyon or in other nearby areas, including the eastern Argus Range and the Cottonwood Mountains. Instead, only the equivalent Late Mississippian Lee Flat Limestone is exposed in these areas. Extensive exposures of Rest Spring Shale, without Lee Flat Limestone, are known to occur further west in the Inyo Mountains and the Last Chance Range. Significantly, both formations are exposed in the Salt Springs area. Both units also are present in the Darwin area, where they apparently are part of a narrow, northeasterly trending band marking the lateral transition between the limestone and shale facies. Because both facies are present at Salt Springs, it seems probable that the Mississippian rocks in this area once were located somewhere within this transition zone several miles south of Darwin. This conclusion tends to confirm the existence of the Butte Valley thrust fault, and indicates that the rocks of the southern Panamint Range are largely allochthonous.

Together with allochthonous Precambrian rocks in the Slate Range, the rocks in the southern Panamint Range north of Butte Valley are thought to comprise part of a once larger allochthonous sheet, here called the Panamint allochthon. The Panamint allochthon probably originated from an area now occupied by the Coso and western Argus Ranges, and at least 45 miles of northeastward movement appears to have occurred on the Butte Valley thrust fault. Previous studies have shown that movement on the fault occurred during the Late Triassic or Early Jurassic, and that movement on the similar Inyo thrust fault in the northern Inyo and White Mountains occurred during the same time period. Results of this study suggest that a nearly continuous belt of major thrust faulting, involving tens of miles of eastward displacement, extended from the southern Coso Range to at least the northern end of the White Mountains.

# # #

MICRO-CRUSTACEANS OF COTTONBALL MARSH

INVESTIGATOR: Richard Watkins
Arizona State University

SUMMARY OF PROGRESS: Micro-crustaceans from Cottonball March (CM) samples collected by R. Naiman (April 1974) and P. G. Sanchez (June 1974) have been tentatively identified as outlined in the following section. Preliminary taxonomic, zoogeographic, and paleozoogeographic conclusions should be completed in the near future. Final conclusions and actual description of the new micro-crustaceans are dependent on aquisition of additional CM specimens and ostracod-type specimens for comparison.

SIGNIFICANT FINDINGS: *Limnocythere* sp.: Cosmopolitan fresh and brackish water genus. Cottonball Marsh specimens resemble *L. staplini* described from Pleistocene deposits in southwest Kansas, also recorded from Pleistocene Wilcox Playa, Arizona, and currently found on the Canadian plains. *L. staplini* is associated with saline waters. *Limnocythere staplini* resembles *L. sancti-particii* and photos of specimens from a lagoon in the Gulf of California assigned to *L. sancti-patricii* appear to more closely resemble *L. staplini*. Ostracodes from the Bouse formation (deposited during the Pliocene embayment of the Gulf of California) included specimens identified as *Limnocythere* or *Ilyocypris*. Establishing the taxonomic relationships of these populations is of obvious interest. Number of specimens--3.

Cyprideis sp.: Cosmopolitan genus considered diagnostic of coastal brackish environments. In the Western Hemisphere it occurs in the Caribbean, Atlantic and Pacific coasts, and south America. The only other North American inland record of *Cyprideis* was of *C. salebrosa* in Pleistocene and Pliocene deposits in southwest Kansas. It was associated with *L. staplini* in the Pleistocene strata. The CM is the only recent population in the Western Hemisphere located so far from a coastal environment. Several species of *Cyprideis* were found in the Bouse formation but were not identified. Ostracodes assigned to *Cytheridea* but probably representing *Cyprideis* were recovered from Miocene nodules collected northeast of Barstow.

Cottonball Marsh specimens are closely related to *C. beaconensis*, described from fossil Pleistocene and living material in the Sunset Beach area and also occurring on north Baja coast of Chile and Oahu, Hawaii (Pleistocene). *Cyprideis beaconensis* type specimens will be obtained to evaluate the minor differences of the CM specimens. Number of specimens--many.

Cletocamptus deitersi and *C. albuquerquensis*: Cosmopolitan genus found in brackish, inland saline and possibly fresh waters. Two species present in Western Hemisphere, both present in CM (first recorded co-occurrence). *Cletocamptus deitersi* recorded from Caribbean, South America, New Mexico, Hawaii (note *Cyprideis beaconensis*), and Tecopa Bore. *Cletocamptus albuquerquensis*: Caribbean, South America, Colorado, New Mexico, Mexico, North Dakota, Saskatchewan, and Soda Lake, Nevada. In addition Miocene fossils of a Cletocamptid very closely related to *albuquerquensis* were found in the Barstow formation not far from the *Cytheridea (Cyprideis ?)* site.

Both the CM cletocamptids have a seemingly unique cone-shaped structure on their maxillules. Neither the *C. deitersi* from Tecopa Bore nor the *C. albuquerquensis* from Soda Lake, Nevada have such a structure. The CM *C. deitersi* and *C. albuquerquensis*, in addition to the Tecopa Bore *C. deitersi* are considered to be new subspecies. Number of specimens of *C. deitersi*--4.

Number of specimens of *C. albuquerquensis*--5.

Nitocra Lacustris: Cosmopolitan species found in marine, brackish, and inland saline habitats. Western Hemisphere records from Caribbean, Bermuda, and the Yucatan Peninsula. No records from the Pacific coast or the Gulf of California have yet been found. Number of specimens--many.

Horsiella brevicornis: Cosmopolitan species, one previous record from Western Hemisphere in El Salvador, only one other Western Hemisphere record for the genus (Brazil). Cottonball Marsh is evidently the first record of the genus *Horsiella* from North America. *Horsiella brevicornis* is found in brackish, inland saline, and occasionally fresh waters. Number of specimens--many.

Halicyclops sp.: Cosmopolitan genus apparently restricted to coastal brackish environments in the Western Hemisphere. Cottonball Marsh is the only inland Western Hemisphere record. Cottonball Marsh, Halicyclops, is probably a new species. More specimens are needed to be certain. *Halicyclops* is found in the Caribbean and on the gulf and Pacific coasts of Mexico. Number of specimens--1.

In addition the macro-crustacean, *Hyalella azteca*, was present in considerable numbers.

Cottonball Marsh contains an interesting and unique micro-crustacean fauna. Evidence concerning the origin and age of this fauna is being compiled, including consideration of possible late Tertiary Pacific and/or Bouse coastal origin.

Future work should include more extensive sampling of Cottonball Marsh both to determine if any additional species of micro-crustaceans are present and to obtain adequate numbers of specimens to describe the new micro-crustaceans already found. Subsequently, consideration should be given to expanding sampling to include the other aquatic habitats in the Death Valley National Monument. Based on the limited work done so far, Cottonball Marsh and the rest of Death Valley appear to have great potential for taxonomic and zoogeographic research.

# # #

DETERMINATION OF TECTONIC STRAIN, DEATH VALLEY

INVESTIGATORS: Arthur G. Sylvester)
Frederick Keller) University of California, Santa Barbara
Richard P. Keller)

SUMMARY OF PROGRESS: Undergraduate geology students of the University of California, Santa Barbara, have been carrying on a long-range project to determine whether or not small movements are taking place along some of the more recent-appearing faults in Death Valley. Benchmarks were placed across the following fault scarps: Death Valley-Furnace Creek; Artist's Drive; and Hanaupah. The arrays of benchmarks have been surveyed since 1970 as many as four times each by means of precision leveling and first-order triangulation. The most recent resurvey of some of the level lines was in September 1974.

Results to date show that no movements have taken place on any of the faults during the period of observation. In fact, reproducibility of the measurements is so close from year to year, even though the work was done by different, relatively inexperienced crews, that we have gained much confidence in our ability to do highly precise work. Many of the monuments are in large boulders on the surfaces of alluvial fans, and if nothing else, our study demonstrates the stability of these boulders over the time span of the study.

In view of the inactivity of these faults, we expect to request permission to expand our surveying coverage to other faults and probably will do the surveying less frequently--perhaps every third year--except in the event of an earthquake in the valley.

Location data for our fault-crossing arrays in Death Valley are summarized in the following publication:

Greensfelder, R. W. 1972. Crustal movement investigation. Special Publication 37, California Division of Mines and Geology.

# # #

MEASUREMENT OF TECTONIC TILTING IN THE DEATH VALLEY AREA

INVESTIGATORS: W. T. Kinoshita) U. S. Geological Survey
G. W. Greene)

SUMMARY OF PROGRESS: Tilting has been measured at five sites within Death Valley National Monument in observations made since May 1958. Thus far it has not been possible to separate tectonic tilting from tilting caused by earth tides, temperature (seasonal) changes, and perhaps other causes. A cluster of continuously recording tiltmeters operated for a minimum period of 6 months (and preferably 1 year) is needed at each site in order to resolve the problem.

We are trying to secure USGS support for the installation of such tiltmeter arrays, although at present the prospects are dim.

During 1974 all five sites were measured twice (once in March and once in November) using first-order leveling instruments and techniques. These data are being reduced now.

# # #

PUPFISH DEVELOPMENT IN CYCLIC AND STABLE ENVIRONMENTS

INVESTIGATOR: Joy Shrode
Arizona State University

SUMMARY OF PROGRESS: Adult *C. n. nevadensis* were collected from Saratoga Springs, California, and bred in the laboratory. Eggs were incubated at constant and diel fluctuating temperatures. Greater than 50% normal hatch occurred between constant temperatures 20 and 36°C and at fluctuating temperatures up to 38-30°C. Tolerance limits for normal egg development parallel temperatures reported for breeding behavior in the field. Critical thermal maxima of young fish were consistently higher than those of older fish acclimated under the same conditions. Tolerance to high temperature is lowest during egg stage, highest in young fish, and intermediate in large adults. There was no significant difference in number of vertebrae in fish which had been incubated at constant temperatures 20 through 36°C, diel fluctuating temperatures 28-29°C, 36-28°C, 38-30°C.

Publication

Shrode, J. B. 1974. Temperature effects on development of *Cyprinodon nevadensis*. Ph.D. Thesis. Arizona State University.

# # #

PALEOENVIRONMENTS OF WOOD CANYON FORMATION

INVESTIGATOR: Paul E. Diehl
Pennsylvania State University

SUMMARY OF PROGRESS: Field work in the Death Valley National Monument has been completed. Stratigraphic sections of Wood Canyon Formation have been inspected and/or measured in Mosiac Canyon, Titanothere Canyon, Echo Canyon--Winters Peak area, and Death Valley Buttes--Boundary Canyon area in addition to several others outside monument boundaries.

Significant findings to date and comprehensive progress is given in Geol. Soc. Am. Guidebook, Cordilleran Sec. Meeting, March 1974. Since that time, thin-section work has been in progress. This consists of quantitative size analysis and composition data of 62 thin sections about half of which are samples from the arkosic conglomerate portion of the lower part of the middle member of the formation.

# # #

INSECTS OF SAND DUNES

INVESTIGATOR: Derham D. Giuliani
California Academy of Sciences

SUMMARY OF PROGRESS: Only one trip was made to Death Valley National Monument, to Saratoga Springs. No dune insects were found on the sand around the ponds in spite of the nearness of the large dunes to the south.

It should be mentioned, however, that a very large variety of Coleoptera and Diptera were found in association with the wet areas indicating the springs have not undergone as destructive a disturbance in the past as have so many other desert spring localities.

# # #

GEOLOGY OF MARBLE CANYON QUADRANGLE

INVESTIGATOR: Edward A. Johnson
U. S. Geological Service

SUMMARY OF PROGRESS: Due to an employment change during the summer of 1974, no field work was undertaken on this project. Hence, the level of completion remains as reported on my last year's report.

The above-mentioned job change was from assistant professor at the University of the Pacific in Stockton, California to geologist with the U. S. Geological Survey in Menlo Park, California. I plan to spend at least 3 weeks in the field during September.1975 on this project, and I am starting the written portion this spring.

# # #

ANNUAL PLANTS

INVESTIGATOR: Lionel G. Klikoff
University of Utah

SUMMARY OF PROGRESS: During the spring of 1972 we gathered data on pollination mechanisms and seed set as related to the annuals of Death Valley. The data are preliminary but it would appear that even in the most unusually favorable years pollinators are not limiting in a competitive sense. Seed set was almost universally high during wet years.

Additional energy ought to be devoted to sorting out of pollinators in relation to annuals, to seed polymorphism, and to the question of the size and maintenance of the soil seed reservoir, the last involving consideration of predator-prey systems as related to seeds.

# # #

SURVEY OF ORGANISMS ASSOCIATED WITH CYPRINODON FISHES

INVESTIGATOR: Laurel L. Walters
University of California, Riverside

SUMMARY OF PROGRESS: Aquatic insects (Coleoptera, Odonata, Diptera, Hemiptera) have not been determined as to species to date. This information will be forwarded as soon as it is available. At Saratoga Springs main pool on 9 August, several crustaceans were noted: large numbers of the Amphipod, *Hyalella azteca* and the cyclopoid Copepod *Macrocyclops albidus* (tentative, sent to Smithsonian for positive identification). Submerged vegetation: *Ruppia maritima* (Ditch Grass) and *Ceratophyllum demersum*.

It appears as though the *Macrocyclops* populations may be negatively phototaxic. High numbers were found at the surface of the main pool at 8 a.m. (pool shaded) whereas none were found at the surface at 12 noon (pool in full sun). Greatest numbers were found within or above *Ruppia* vegetation. Pupfish were observed feeding vigorously and in large numbers in or on *Ruppia* at a 3 ft depth at 12 noon and few at 8 a.m. Perhaps *C. nevadensis nev.* utilize *Macrocyclops* and/or *Ruppia* as partial food sources.

Some physical data were also obtained:

Saratoga Springs, 9 August, main pool, 8 a.m.

Temp: 28.5-29.0°C
pH: 7.6-7.7
Sp. Grav.: 1.000
Dissolved O_2:
3 ft depth: *Ruppia* 5.0 ppm
Bottom: 4.5 ppm

Salt Creek, 11 August, scattered pools ½-1 mile from parking, 6:30-8 a.m.

1. Temp.: 21°C
pH: 8.0
Sp. Grav.: 1.028
Dissolved O_2: 2.1 ppm

2. Temp.: 23°C
pH: 8.0
Sp. Grav.: 1.024
Dissolved O_2: 2.6 ppm

3. Temp.: 23°C
pH: 8.6
Sp. Grav.: 1.022
Dissolved O_2: 2.5 ppm

# # #

MONOGRAPHIC STUDY OF *BOERHAAVIA, ASTRAGALUS*; SOUTHWESTERN FLORA

INVESTIGATOR: Richard Spellenberg
New Mexico State University

SUMMARY OF PROGRESS: *Boerhaavia.* Study is complete. Our findings indicate that *B. annulata* of Death Valley is truly *Anulocaulis*. Evidence in chromosome number of $2n = 48$, flavonoid pattern in paper chromatography very similar to Texas *Anulocaulis*.

Astragalus. Study is 90% complete. No change from last year. The *A. layneae* from above Titus Canyon confirms my earlier count from same species in Panamint Mountains. Species is tetraploid, $2n = 44$, unusual in *Astragalus*. No other collections made.

The southwestern flora study is moving satisfactorily. Noel Holmgren is in charge and can better answer questions. My contribution from the Death Valley area was to supply about five interesting collections; I will also contribute the treatment of the Nyctaginaceae later.

No publications yet. Copies will be supplied when available.

# # #

GEOLOGIC MAPPING OF TELESCOPE PEAK QUADRANGLE

INVESTIGATOR: Ardon L. Albee
California Institute of Technology

SUMMARY OF PROGRESS: A preliminary copy of the map was compiled and sent to the state for their use in revising the 1,250,000 scale Death Valley sheet, and a copy is in NPS files.

Final completion will be some years away because my current involvement in the Lunar Sample programs prevents my spending much field time in the area.

# # #

PEROMYSCUS MANICULATUS (DEER MICE)--GENETIC DIFFERENTIATION AMONG POPULATIONS ALONG ALTITUDINAL GRADIENTS

INVESTIGATOR: Lee R. G. Snyder
Stanford University

SUMMARY OF PROGRESS: I am continuing to sample populations of deer mice in the Great Basin area in eastern California but during the past year I did not collect within Death Valley National Monument itself.

SIGNIFICANT FINDINGS: In my study of red blood cell proteins, I have discovered several previously unreported genetic variants for the proteins hemoglobin and 6PGDH. However, I have found no evidence for genetic adaptations to high or low altitude.

PLANS FOR 1975: I have no immediate plans for further work in Death Valley but I hope that future policies will not only permit but will encourage biological and ecological research on federal lands, national parks, etc. Only through continuing research will we know just how valuable and unique these areas are. For instance, in my research I have discovered that the White Mountain Bristlecone Pine Forest (a preserve near Death Valley) supports a population of genetically unique deer mice--genetic types which have not been found anywhere else in the North American continent. Their unique genetic constitution may reflect adaptation to the harsh environment of that area.

# # #

ENERGY BALANCE IN THE RAVEN IN DRY HEAT

INVESTIGATOR: H. Craig Heller
Stanford University

SUMMARY OF PROGRESS: I regret to report that I was unable to find sufficient free time this past summer to initiate our planned research on the energy balance of ravens living in extreme dry heat. I am hoping I'll have better luck next summer.

# # #

CENTRAL NERVOUS SYSTEM REGULATION OF TB IN THE ANTELOPE GROUND SQUIRREL

INVESTIGATOR: H. Craig Heller
Stanford University

SUMMARY OF PROGRESS: Our research on the antelope ground squirrel is in purely physiological stages, therefore, we collected our animals outside of the park. If in the future we extend our work to the ecological aspects of the problem, I would work within Death Valley.

# # #

NATURAL HISTORY INVENTORY, SCOTTY'S CASTLE & RANCH

DEVA-N-16

INVESTIGATOR: Charles L. Douglas

SUMMARY OF PROGRESS: A major collecting trip was conducted in May of 1974 with eight graduate students from University of Nevada. Two days and nights were spent in the ranch area, during which time more than 65 species of plants were recorded from the ranch and spring areas. Mammals were trapped in Sherman Live Traps. Birds were surveyed and found to be abundant. Various species of reptiles were recorded; lizards are especially plentiful in the ranch area. One species of amphibian, *Bufo punctatus*, was found. The castle area was visited on two other occasions but collections were not made.

Plans for the next field season include seasonal surveys of birds and mammals. We plan to visit the ranch earlier in the spring of 1975 since many annuals have ceased blooming by May. Additional live trapping will be conducted to assess the mammalian populations.

# # #

A NEW GENUS AND SPECIES OF EUOMPHALACEAN SNAIL FROM THE WESTERN U.S.

INVESTIGATOR: Kevin E. Ahern
California Academy of Sciences

SUMMARY OF PROGRESS: Trips were made to the monument in the spring of 1974 and material collected at sites in the Grapevine Mountains.

This material was examined and the results of the examination will be used in: (1) the researcher's M.A. thesis at the University of California, Berkeley, and (2) the publication of a new genus and species of gastropod, *Hesperomphalus transformatus*.

A copy of (2) above will be forwarded as soon as it is completed; as it will contain much of the data specifically pertinent to the monument used in (1), no copy of (1) will be forwarded to the monument unless specifically requested.

It is anticipated that another year will be required to complete the project. At least one additional visit to the Grapevine locality is anticipated; I presume in the late spring of 1975.

# # #

BURRO ECOLOGY AND MANAGEMENT
DEVA-N-02A

INVESTIGATOR: Charles L. Douglas

SUMMARY OF PROGRESS: This project is combined with DEVA-N-11 entitled, *Burro Activity Evaluation*. The two studies are inseparable since they involve general ecology of feral burros and their interaction with the environment and with other species.

Approximately 40 burros have been handled in the past year. The animals are tranquilized, restrained, measured, weighed, and aged by tooth wear, blood is drawn for physiological studies, the animals are tagged, and released. Data are being gathered on movements of marked animals. This is a time-consuming process that will be facilitated by utilization of radio telemetry collars that were recently received. We plan to continue marking individuals, and will place transmitter collars on five or six animals. These will be monitored once a month by air and weekly by ground survey.

Four burros were tested for physiological parameters under controlled environmental conditions. Radioisotopes were used to determine total body water, life of red blood cells, etc. Considerable new data were obtained by means of these experiments.

Parasitic examinations to date have been negative, but these will continue. Fecal materials and blood are being examined for coccidia and Toxoplasma, respectively. This work is being conducted, *gratis*, by a colleague at the University of New Mexico.

# # #

MORTALITY OF DESERT HOLLY
DEVA-N-5

INVESTIGATOR: Jack C. Fisher, Jr.
National Park Service

SUMMARY OF PROGRESS: Two continuous Mast ozone monitors were installed in Death Valley, one at Furnace Creek and one at Scotty's Castle. These will continue to run until the termination of the project. Significant records have been obtained which establish high ozone levels in Death Valley at 1.6 ppm, two times the national standard for plant damage (of 0.08 ppm). The ozone has been established to be present predominantly during the summer months, dropping in the winter to levels considered normal background for remote desert areas.

Previously established plant transects were rerun during the summer and, in general, a slight improvement in the community was recorded. This was to be expected considering the relatively good rains of the previous year. Similar community improvement in Desert Holly has been noted by Estella Leopold (pers. comm.) of the USGS, at the China Lake Naval Weapons Center. However it should be stated that reproduction and establishment of new plants is still below the rate of mortality, as determined by the formerly mentioned transects.

Fumigation chambers for ozone fumigation of *Atriplex hymenelytra* in filtered-air greenhouses at UCR have been obtained and the plants to be fumigated are being potted in Domino Silt loam. A soil moisture release curve is being run on the Domino Silt loam using the pressure plate apparatus of the Department of Soil Science at UCR. By knowing the percent water at various matrix suction levels of the soil, we can grow the plants under controlled water stress. Fumigations will be conducted using levels of ozone known to be present in Death Valley. By measuring the effect of ozone on water-use efficiency of plants under controlled water stress, we hope to determine the significance of ozone to survival of *Atriplex hymenelytra*. Duplicate experiments are being run on *Larrea divericata* which is also expressing symptoms of deterioration in Death Valley (see Desert Holly Report, September 1973), identical to those symptoms found in *Atriplex hymenelytra*.

We hope to be finished with the fumigation experiments by September 1975.

# # #

STUDIES OF DESERT HOLLY, *ATRIPLEX HYMENELYTRA*, IN DEATH VALLEY
DEVA-N-5

INVESTIGATOR: Jack C. Fisher

OBJECTIVES: To determine causes of the die-off of Desert Holly plants in Death Valley, and possible management options for preservation of this species.

SUMMARY OF PROGRESS: Plant transects have been completed at the field stations for the second year and show some community improvement. This is also the case with the *Atriplex hymenelytra* community in the Argus Mountains west of Death Valley, being studied by Estella Leopold of the USGS (pers. comm. 1974). Some improvement is to be expected in view of the fact that the three past rainy seasons have brought relatively large amounts of water to the desert. However, the rate of establishment of new plants in Death Valley is still below the rate of die-off.

Two continuously operating Mast ozone monitors with strip chart recorders were installed in July in Death Valley, one at Furnace Creek at the NPS headquarters and one at Scotty's Castle. To date, the ozone concentrations have been recorded to go as high as 0.16 ppm, which is twice the national standard for plant damage. Higher than normal concentrations of ozone come into Death Valley, predominantly during the summer months with peaks in August and September. This is the same period of time when Southern California experiences hazardous ozone concentrations. According to O. C. Taylor of the Statewide Air Pollution Research Center, the pattern of buildup of ozone in Death Valley is similar to the pattern for Palm Springs. Ozone readings of 0.1 ppm and higher for periods of 24 hours or more are not uncommon.

In January, *Atriplex hymenelytra* and *Larrea divericata* seeds were germinated. The plants are now 1-year old and have been grown in pots in a filtered-air greenhouse at UCR. Twelve plants of each species will be used in the fumigation experiment. Fumigation chambers have been obtained from the Statewide Air Pollution Research Center but these must have 1.5 ft added to their height to accommodate the plants and their containers. The chambers are 2 ft X 2 ft at the base and are made of lacquer wood frames covered with transparent mylar film. O. C. Taylor has committed an ozone-making apparatus to the experiment.

Larrea divericata, Atriplex hymenelytra, and *Ambrosia dumosa* were fumigated in February with ozone in order to establish the characteristics of acute damage. Cellular damage due to fumigant chemicals resulted in plasmolysis and eventually in the collapse of cell walls, with the cells remaining connected to one another at the poles. When large areas of cells are damaged, the necrosis associated with acute damage develops.

This acute ozone damage syndrome, as expressed in clutivated plants, is unaltered in these desert shrubs. Variabilities in the degree of damage for different ozone levels and for different periods of exposure were noted. With *Ambrosia dumosa* exposed to 0.25 ppm for 4 hours, 0.5 ppm for 2 hours, and 1.00 ppm for 2 hours, damage was heavy for the first treatment and moderate for the last two treatments. This suggests that, rather than simply how much ozone is in the atmosphere, the amount of ozone entering the leaf is significant.

Diffusion of gas into leaves is dependent upon Fick's law and an antalog of Ohm's law and can be written by

$$E = \frac{\Delta(\text{gas})}{R}$$

where E = rate of transfer g/cm^2/sec, Δ (gas) = difference between the concentration of that gas in the atmosphere and in the leaf, and R = resistance to diffusion in sec/cm. This equation is commonly applied to diffusion of H_2O as vapor out of leaves and CO_2 into leaves and respectively gives transpiration rates and CO_2 assimilation rates. We can here apply it to give ozone exposure rates by measuring Δ (O_3) and R for ozone diffusion.

As ozone is taken into leaves, it reacts with mesophyl tissues, damaging membranes. Such damage to chlorophyl-containing tissue will possibly result in reductions in photosynthetic efficiency, as expressed by $E = {}^{P}/P_M$ where E is the carbon dioxide assimilation ratio. P is the observed assimilation rate as limited by all diffusional and biochemical resistances and P_M is maximum rate at which CO_2 assimilation could proceed if it were limited by only R_S (stomate resistance) at a given CO_2 concentration (Johnson 1974).

By determining P_M and then obtaining P at given time exposures to low levels of ozone, we can determine the effect of ozone on photosynthetic efficiency. In desert perennials such as *Larrea* and *Atriplex h.*, which are evergreen, reductions in this efficiency during critical times of the year could have much survival significance.

Using Tritium and $^{14}CO_2$, we can measure the P value and the P_M value respectively for plants exposed to ozone under different water stresses. The water stress aspect is of the utmost significance for several reasons. According to records of the ozone monitors continuously operating in Death Valley, high levels of ozone incidence are experienced during summer months when perennial plants are under the most severe water stress. It is known that water stress induces increases in leaf resistance to water vapor diffusion in order to conserve H_2O. Also, as water stress goes up in desert plants, efficiency at which photosynthesis occurs increases such that the result is a maximum utilization of the CO_2 taken in.

Water stress in tissues of plants grown in soil is a function of two factors: the amount of water in the soil and the amount of soluable salts in the soil. As soils dry out, the energy with which the adsorbed water is held increases, becoming more negative. This is termed the matric suction. As matric suction increases, the percent of water in the soil decreases. A soil moisture release curve for the soil to be used in this experiment is presented in the following graph.

The osmotic component of this energy relationship is dependent upon the salts dissolved in the soil water and is a linear function with percent water. The soil moisture release curve has been calculated by the pressure plate technique with the use of the Pressure Plate apparatus of Canell of the Department of Soil Science, University of California, Riverside. The soil was collected in September 1974 from the Moreno Experiment Station of the University of California, Riverside. It is Domino silt loam and has a high percent of montmorillonite clay, which is typical for desert soils.

Plants can be grown in this soil and watered according to a water loss schedule such that the plant is exposed to an average water stress as a matric suction, measured by thermocouple psychrometers belonging to Hyrum Johnson of the Department of Biology, University of California, Riverside.

The plants can then be exposed to ozone, photosynthetic efficiency measured and compared to measurements on control plants. Thus the significance of ozone to desert ecosystems can be assessed.

Over 400 voucher specimens of plant material collected from the nine study stations have been identified with labels typed and given to the herbarium at DEVA for accession and redistribution.

Field studies in plant-water relations were conducted during the summer months in Death Valley using a Scholander pressure bomb and Hygrodynamics porometer system. Diurnal fluctuation, from sunrise to sunset, in xylem tension and transpiration, was measured at two of the study stations, at 150 ft and 600 ft, for July and August.

Phenology on all plants at six of the nine stations has been noted at least once a month. This gives an elevational transect ranging from 150 ft to 3000 ft and illustrates the physiological activity state of the plants during the yearly cycle.

Spot ozone monitoring was done in the field in and around Death Valley using a battery converter borrowed from Paul Miller of the U. S. Forest Service and a small strip chart recorder borrowed from James Ouimette of the China Lake Naval Weapons Center. This series of monitorings illustrates the removal of abnormally high levels of ozone from the atmosphere with the incidence of a strong northeast wind.

In personal communications with Ouimette, it has been learned that the China Lake area has received ozone levels in excess of 0.1 ppm with the same pattern of night time buildup as Death Valley. The continued monitoring in Death Valley through this winter and spring will establish dates when ozone starts to occur in abnormally high concentrations. It is now expected to be in April and May that increased readings will begin.

Publication

Johnson, H. 1974. Gas exchange strategies in desert plants. Chapter 7 *in* Perspectives of biophysical ecology. Springer-Verlag pub., in press.

# # #

INTERACTION OF DESERT BIGHORN SHEEP AND FERAL BURROS IN DEATH VALLEY AND VICINITY

DEVA-N-2A

INVESTIGATOR: Thomas P. Davis

OBJECTIVES: (1) To study movements of burros within Death Valley and vicinity by means of radiotelemetry and direct observation; (2) To study utilization of springs and rangelands by marked individuals, and to determine the relationship to bighorn habitat and watering sources; (3) To determine stress elicited by water deprivation, heat, and extreme cold during winter as reflected by blood volumes and body fluids. The relationship of such stress to seasonal movements, water resources, and management objectives.

SUMMARY OF PROGRESS: Movements of burros were noted by observing tagged burros in different areas of the monument and logging such observations. Tagged burros were observed to move 10-15 miles from the wildrose trap within 3 hrs time. Two burros have been captured and, in order to study movements, radiotelemetry equipment is being fitted to collars for these animals.

Utilization of springs and rangelands is being studied by placing time-lapse cameras at the springs to observe any interaction between burros and bighorn sheep.

Four juvenile burros, 5-14 weeks of age, were studied under controlled laboratory conditions to determine their ability for adaptations to both hot and cold stress as seen in Death Valley. This study consisted of determining fluid volumes and respiratory metabolism during rest and stress.

Through respiratory metabolism measurements (VO_2) one can measure the energetic cost to the animal of varying stresses such as temperature and diet. It was shown that as the temperature drops from 16°C to 8°C, oxygen uptake (VO_2) increased from 6.01 to 8.03 ml/kg min in the oldest burro having the shortest coat. While the other burros maintained a steady VO_2 due to insulation from their baby coat.

Fluid volumes were determined by means of radioisotopes. Red blood cell, plasma, extra- and intracellular fluid, and whole blood volumes were determined. These values can be utilized for studying shifts in fluid volumes during the heat stress of the summer months in Death Valley.

Body water, water turnover rate, and turnover time were studied to gain some insight into the water need of these desert ungulates as related to other desert ungulates such as the bighorn sheep.

Tagging, measurements, and blood sampling have continued. No parasites, infection, or disease has been found in the blood. Samples of plasma from 40 burros have been sent to the University of New Mexico for examination for the parasite *Toxoplasma*, but no information has been received on this to date.

PLANS FOR 1975: Burros will be monitored by means of radiotelemetry for some insight into their movements in the valley.

Tagging and measuring will continue for further information on population movement and growth of individuals in the monument.

Film from the time-lapse cameras will continue to be collected for analysis of burro-bighorn interaction at springs and water holes.

Possible methods of rapid and inexpensive sterilization of burros is presently being sought through personal contacts. The feasibility of using a new sonar sterilization technique is presently being studied. I plan to interview the developer and gain all information needed to do such work.

# # #

BUTTERFLY FAUNA OF THE DEATH VALLEY REGION

DEVA-N-I

INVESTIGATOR: John F. Emmel
Los Angeles County Museum of Natural History

SUMMARY OF PROGRESS: On 15-16 June 1974, collecting was done in several localities in Panamint Range, namely, Surprise Canyon, Water Canyon (above Panamint City), and upper Wildrose Canyon. The following species were collected or observed:

Papilio indra subsp. (immatures on *Lomatium parryi*)
Nymphalis californica
Chlosyne palla vallismortis
Incisalia eryphon
Mitoura spinetorum
Mitoura siva siva
Leptotes marina
Plebejus icarioides subsp.
Plebejus lupini monticola
Philotes enoptes subsp.
Glaucopsyche lygdamus subsp.
Celastrina argiolus cinerea
Hesperia harpalus
Ochlodes yuma

RECOMMENDATIONS: Future collecting on dates earlier and later in the season should expand this list of species. A number of other butterfly species are known from the monument area but their distribution has not been carefully worked out.

# # #

SUPPLEMENT DEATH VALLEY HERBARIUM

DEVA-N-I

INVESTIGATOR: W. D. Dakan
Native Plant Society

SUMMARY OF PROGRESS: Early in 1974 I worked with ranger Kencox in the Death Valley Herbarium and Library. We were looking for a check list of the plants of Death Valley by W. B. McDougal.

Roxana S. Ferris, in her book, *Death Valley Wildflowers*, mentions a list of about 600 species and she thought there might be as many as 900 or 1000 species.

From what I was able to find out, very little has been done on the herbarium since the time of French Gilman. Much remains to be done. I feel many plants could be added to the list.

The check list needs to be revised and its nomenclature brought up to date. It would then be very useful to other botanists and to the general public.

# # #

INSECTS OF SAND DUNES IN WESTERN NORTH AMERICA
DEVA-N-I

INVESTIGATOR: Fred G. Andrews
California Department of Agriculture

SUMMARY OF PROGRESS: In April 1974 I made one trip to Saratoga Springs and collected on the low dunes west of the permanent water area.

I am currently involved in writing a contract with the Office of Endangered Species to study coleopterous insects associated with sand dunes. If this contract is completed, I will be making four trips to the Saratoga area in the next year.

I would like to extend my permit to collect dunal areas in Death Valley for 2 more years. I will turn in a report of my findings at the end of this time, in addition to determined specimens for your collection.

# # #

MONITORING *CYPRINODON DIABOLIS* (DEVILS HOLE PUPFISH) POPULATION AND ECOLOGICAL PARAMETERS AT DEVILS HOLE
DEVA-N-08A

INVESTIGATOR: James E. Deacon
University of Nevada, Las Vegas

SUMMARY OF PROGRESS: The population size of *Cyprinodon diabolis* averages one-half to one-third the original population size. Winter populations appear to be dependent on debris for food. Summer populations appear dependent on algal production and size of habitat. It is apparent that water level is an important factor controlling population size.

It is important to reorient the program somewhat after 1 July 1975 to provide for less disturbance to the population. The current project should continue as planned to 1 July 1975. Continuation of the project indefinitely at about the same intensity of effort appears desirable at this point.

For additional detail with respect to findings and recommendations, refer to monthly reports.

# # #

GEOLOGY OF SKIDOO--TUCKI MOUNTAIN AREA, PANAMINT RANGE
DEVA-N-I

INVESTIGATOR: Edward W. Hildreth

SUMMARY OF PROGRESS: Only a few days further mapping were completed in 1974. During 1975 the project will remain on a "spare-time" basis, but a reasonable likelihood (currently unassessable) exists that intense work will be resumed in 1976-77.

# # #

SEDIMENTOLOGY OF ZABRISKIE QUARTZITE
DEVA-N-I

INVESTIGATOR: John J. Barnes
University of Illinois

SUMMARY OF PROGRESS: No changes since last year. Anticipated completion April 1975.

# # #

JOSHUA TREE ECOLOGY

INVESTIGATOR: Peter L. Comanor
University of Nevada, Reno

SUMMARY OF PROGRESS: Initial inventory and observations have only just begun and reproductive status needs to be examined closely. Future course of action will involve long-term monitoring of plant population parameters. I propose a long-term study (perhaps 20 years) of growth rates and survival, etc., of *Yucca brevifolia*. The study would include Death Valley as a part of a larger study. Within 5 years from the initiation data should be available for use by NPS.

# # #

PETROGRAPHY OF OWLSHEAD MOUNTAINS

INVESTIGATOR: James P. Calzia
Univeristy of Southern California

SUMMARY OF PROGRESS: The plutonic complex in the southeastern Owlshead Mountains consists of Mesozoic alkali syenite and granites that have intruded folded marble of Precambrian or Paleozoic age. Both the marble and the plutonic rocks are overlain by a thick sequence of hornblende andesite flows and fanglomerate deposits of Tertiary age. Hornblende diorite dikes, mineralogically similar to the andesite flows, are found in the marble and plutonic complex but not in the Tertiary deposits. Emplacement of the Owlshead plutonic complex involved passive intrusion, assimilation, piecemeal stoping, and contact metamorphism of the marble. The intrusive sequence is (oldest first): (a) quartz-bearing alkali syenite; (b) red biotite granite; (c) gray biotite granite; and (d) alkali granite. The modal composition of the granites, plotted on isobaric equilibrium diagrams, and the pressure limitations dictated by the mineral assemblage of calc-silicate skarn zones found adjacent to intrusive contacts in roof pendants of marble, indicate the Owlshead plutonic complex probably crystallized from hydrous alkalic magmas at temperatures near 800°C and pressures equivalent to crustal depths of 1 to 1.5 km.

Tertiary andesite flows and fanglomerate deposits unconformably overlie the Owlshead plutonic complex. The oldest fanglomerate deposit, the marble boulder fan, probably was deposited during erosional unroofing of the granites; erosion may have been caused by uplift of the plutonic complex along north-south or northwest-trending faults that predate the Tertiary deposits. The marble boulder fan and overlying gneissic boulder fan may be older than the andesite flows and related tuffaceous or bentonitic sediments as suggested by the absence of volcanic detritus in these fans. A slide block in the volcanic deposits and folds in the marble boulder and gneissic boulder fans are unconformably overlain by granitic boulder and volcanic boulder fans. The elliptical plan of the Owlshead Mountains and the outward dips of the Tertiary deposits around most of the periphery of the mountains indicate the Owlshead plutonic complex and overlying volcanic and fanglomerate deposits form a broad dome. Unconformities between the Tertiary deposits and the tectonically increased dips of Quaternary stream terraces indicate recurrent uplift and doming of the Owlshead Mountains during the Tertiary and into Quaternary time. Fault-controlled interior basins, filled with Quaternary alluvial and playa deposits, suggest relatively recent collapse of the central part of the Owlshead dome. Manganese ore mineralization, younger than the marble boulder fan but older than late Pleistocene lake deposits, probably is associated with Tertiary volcanism and is not related to the plutonic complex.

Petrography and petrology are to be published within the next year. Copy of M.S. thesis in library, Department Geological Sciences, University of Southern California.

See map, page 99.

# # #

PHOTOSYNTHETIC ADAPTATION OF PLANTS TO HIGH TEMPERATURES

INVESTIGATORS: Olle Bjorkman, Carnegie Institution of Washington
Harold Mooney, Stanford University

SUMMARY OF PROGRESS: During the year we have completed the establishment of our experimental transplant gardens on the floor of Death Valley and at a coastal site at Bodega Head just north of the Point Reyes Peninsula. Our controlled growth facilities (phytocells) at the laboratory at Stanford have also been completed and they work to our full satisfaction. With these units it is now possible to simulate the temperature and water regimes of extreme natural habitats, including those of our transplant sites, while maintaining all other environmental factors under close control. A third unit is now being constructed with funds from the Carnegie Institution. The new computer-based mobile laboratory unit and associated stationary laboratory facilities for measurements of environmental variables in the field and of physiological responses of our experimental plants also have been fully equipped and now operate to our full satisfaction. Considerable progress also has been made in our experimental work, currently focused on adaptation of plants to extremes of temperatures and water stress.

FUTURE WORK: Our immediate studies are focused on the molecular mechanisms underlying the striking differences in thermal stability between *T. oblongifolia* and *A. sabulosa*. These studies will include comparative measurements of the quantum requirement for photosynthesis in intact leaves under a wide range of temperatures, kinetic studies of photosystem 2 fluorescence by leaf discs infiltrated with DSMU and measurements of membrane permeability of leaf tissue slices in response to temperature. The studies may also be extended to include the temperature dependence of different component reactions of photosynthesis in isolated chloroplasts and of the galactolipid and sulfoilipid composition of photosynthetic membranes.

Studies will also be conducted to uncover other mechanisms underlying environmentally induced temperature acclimation of photosynthesis which are unrelated to thermal stability of C_4 photosynthesis. Our studies have shown that this kind of acclimation occurs in C_3, C_4 as well as CAM plants and suggests that it involves quantitative changes in the relative capacities of different component steps of photosynthesis. It also appears possible that changes in the temperature dependence of *affinity* of the carboxylation enzymes for CO_2 may be involved in this acclimation. This possibility will be explored.

In addition to this work at the cellular and subcellular levels our studies at the whole

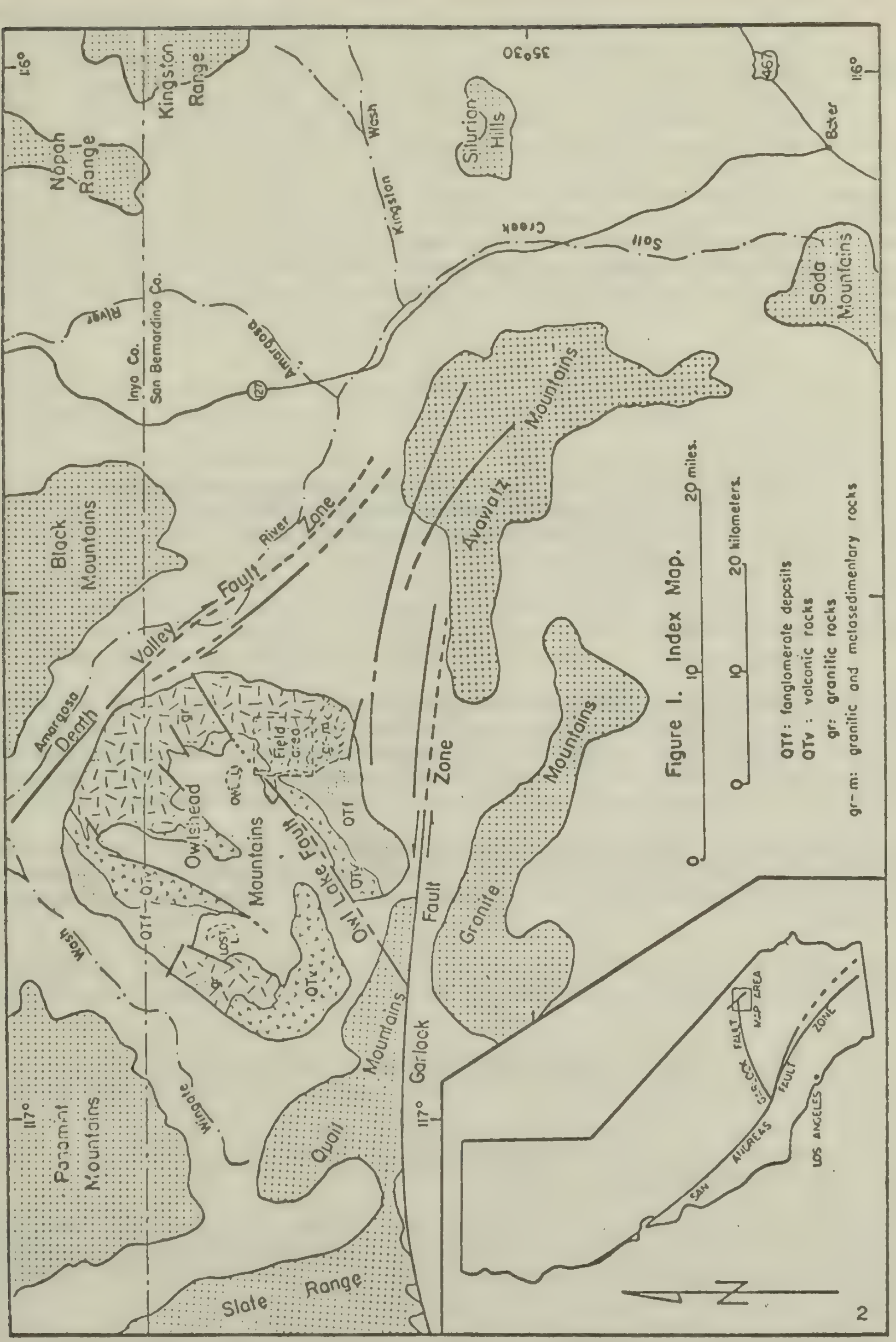

Figure 1. Index Map.

plant level, both in the field and laboratory, will be continued during the coming year. We fully recognize that in order to make realistic and ecologically meaningful evaluations of the adaptive significance of the various differences in metabolic function and in structural characteristics it is necessary that this work is continuously integrated with more general studies of environmental relationships, timing of activity and overall performance in nature. During the coming year we plan to continue our detailed studies of the phenology, growth responses and photosynthetic performance in Death Valley and Bodega Head as well as under controlled conditions of several of the species now under intensive study.

These studies will also be extended to include *Larrea tridentata* and *Prosopis juliflora*, both C_3 species which retain their leaves throughout the summer in their native habitats on the floor of Death Valley. This should shed further light on the adaptive significance of different photosynthetic pathways and provide an insight into what adaptive strategies have evolved that enable plants to inhabit and co-exist in one of the most extreme environments on earth.

# # #

INVESTIGATIONS OF THE MOVEMENTS AND ECOLOGICAL REQUIREMENTS OF THE COLORADO SQUAWFISH AND HUMPBACK SUCKER IN THE YAMPA AND UPPER GREEN RIVERS

INVESTIGATORS: Karl Seethaler
Chuck McAda

SUMMARY OF PROGRESS: Some preparations were made during the winter and spring. A proposal was submitted in which a general outline of the project was presented. Some equipment was assembled. Correspondence was conducted with Charles Zeibell at Arizona Cooperative Fishery Unit, University of Arizona, Tucson. Arrangements were made to purchase 10 sonic tags each summer (1974 and 1975) from Donald Brumbaugh of Tucson.

From 8 June through 14 June a river trip was taken through Desolation Canyon on our newly acquired raft for the purpose of area familiarization and developing certain techniques in floating the river and seining for fish. On one seine haul, we captured nine squawfish and two bonytail chubs.

From 15 June through 15 July our time was spent in acquiring equipment, obtaining permits, talking to people within whose jurisdiction we would be working and other coordinating activities.

On 24 June, I flew to Tucson to learn from Dr. Zeibell the technique of inserting sonic tags in the abdominal cavities of fish. We consulted on various problems that might be encountered.

On 16 July we went to Echo Park. We seined, trapped, and set nets for 2 days, catching creek chubs, carp, and flannelmouth suckers.

On 19 July we set up camp at Box Elder Campground. Trammel nets were set. We began catching a number of fish including flannelmouth suckers, bluehead suckers, channel catfish, black bullheads, carp and roundtail chubs, but no squawfish until 29 July. It was dead in the net.

The morning of 30 July we captured a second squawfish. It was in good condition, so I inserted a tag at midday, but decided not to release it right away to see how well it would recover. The next morning it was still apparently in good condition but by evening its condition was poor. It was dead the next morning.

Over the next few days, additional squawfish were captured until a total of 13 had been caught by 6 August. Most were dead within 2 days of capture. The last three were captured on the morning of 6 August. Our outboard engine had been getting steadily worse and finally became inoperative on that morning. We had to paddle the John Boat. This took some time. The last fish weighed over 6 lbs., twice as large as any of the others. It was dead, possibly due to the delay in retreiving it caused by the outboard failure. The other two were in good condition and were placed in live nets.

We pulled the nets and paddled the boat with the outboard to Echo Park. Grand Junction was the nearest place that a repair could be made. We arrived back at Dinosaur on the evening of 8 August.

On the morning of 9 August we set out from Echo Park to Box Elder but did not make it with the boat. A poor job of repair had been done on the engine. We walked to Box Elder to check the fish. One was almost dead and died shortly after our arrival. The other was still in very good condition. It was so lively in fact that it surprised me and escaped.

The outboard was returned that evening to Grand Junction to be repaired again. On 10 August it made the trip from Echo Park to Box Elder, but just barely.

In desparation, we decided to set three nets close to camp and work without the outboard. On the evening of 11 August we caught our last squawfish. It was still in good condition on the morning of 12 August and a tag was inserted. We turned the fish loose immediately after it recovered from the operation. It immediately went to the other side of the river where it remained stationary for 3 hours. Then it began swimming down river. I followed it until the end of the day when it reached the channel between the Green and Yampa rivers at Echo Park. By then the signals were coming in very weakly and erratically with loud static. The wires on the hydrophone were badly frayed. The day was, however, the biggest success of the summer. The system was shown to work.

The next few weeks were plagued with more equipment problems. We returned to Logan to exchange outboards. The second outboard also gave us too many problems to be of much use. Then we had problems with the shocking boat which took some time to repair. Finally, in early September, we did some shocking on the Green River below Split Mountain and some seining on the White River and again at Echo Park.

In many respects, the results of our efforts this summer were disappointing. We had trouble keeping our fish alive and we had trouble with our equipment. Moreover, we probably had too much equipment, so that our mobility was not all it should have been.

# # #

EVERGLADES NATIONAL PARK

SHARK SLOUGH ALLIGATOR STUDY
EVER-N-34

INVESTIGATOR: John C. Ogden

SUMMARY OF PROGRESS: The initial phase of this project was completed in 1973, an analysis of alligator nesting success correlated with surface water conditions. These data will be prepared in a report when I have time, and copies made available to the park. A monthly survey of alligator numbers along L-67 on the east park boundary was continued through early 1974, and should be continued by other park personnel as a measure of long-term alligator population trends, correlation between alligator movements and water conditions, and characteristics of alligator age-grouping. The long-term goal of the study, to investigate alligator population dynamics and size of the population, was not undertaken prior to my termination at Everglades National Park.

# # #

FLORIDA BAY FISHERIES RESEARCH PROJECT

EVER-N-36

INVESTIGATOR: Thomas W. Schmidt
National Park Service

OBJECTIVES: Primarily, to develop and conduct an ecological survey in Florida Bay in order to most effectively describe the community of ichthyofauna and invertebrates inhabiting a particular area and derive a basic understanding of spatial distribution, determine how sport and commercial fishery population change and quantify as best as possible the numbers and weights of the individuals per unit area.

METHODS: Northwestern Florida Bay monthly fish collections by seine were completed during June 1974. Quarterly collections by seine began in September 1974. Otter trawl sampling in northwestern Florida Bay was conducted from January through December 1974. Trawl sampling in Central Florida Bay began in September 1974.

RESULTS AND DISCUSSION: A total of 106,659 fish distributed among 129 species and 52 families were taken by seining and trawling from regular monthly and quarterly collections from May 1973 through November 1974. Fish habitat biomass estimates (gm/m^2) were determined monthly by seine and trawl in northwestern Florida Bay through September 1974. Studies are on schedule and should continue as planned.

# # #

FLORIDA BAY BENTHIC MAPPING PROJECT

EVER-N-37

INVESTIGATOR: Thomas W. Schmidt
National Park Service

OBJECTIVES: To characterize and map Florida Bay benthic features through the utilization of aerial photography and ground-truth surveys.

METHODS: Methodology includes aerial photography through the utilization of orthophotography supplemented by biological sampling gear.

RESULTS AND DISCUSSION: Representative benthic habitats have been characterized in northwestern Florida Bay from ortho-photography and area measurements of habitats were determined by the preferred dot grid method. Estimates of fish biomass were then defined in terms of kilograms per hectare from the results of area measurements in northwestern Florida Bay. Studies should continue as planned.

# # #

SPORT FISHERY STUDY
EVER-N-53

INVESTIGATOR: Gary E. Davis
National Park Service

SUMMARY OF PROGRESS: Previous work on the sport fishery at Everglades National Park has shown that long-term trends in the availability of sport fish such as spotted sea trout, grey snapper, and red drum were associated with spawning aggregations and drastic changes in environmental conditions, particularly salinity fluctuation, and that no long-term trend could be attributed to the effect of human harvest on the fish populations. However, due to small sample sizes and large variation in catch rates, significant fluctuations in fish abundance could not be detected in time periods less than 1 year which prohibited evaluation of seasonal change. Further, it was shown that for most species found in the study area, sample size could not be increased sufficiently to precisely reflect changes in abundance. In 1972 the National Park Service began development of a data acquisition program based on this earlier work to provide more precise estimates of total human harvest and the relative availability of sport fish in Everglades National Park. The five changes in data acquisition and analysis of data were made to improve the precision of these estimates: (1) the fishing population was stratified to reduce catch variability between fishermen of different skill levels; (2) the measure of fishing effort was made more restricted to include only the time actually spent fishing as opposed to the total time away from the dock used by the earlier workers; (3) the total number of fishing parties interviewed each month was doubled; (4) aerial surveys were used to estimate total fishing effort rather than general visitation figures used previously; and (5) catch rates were tabulated by the straight regression line technique described by Caillouet and Higman (1973). A general summary of the sport fishing activity in Everglades National Park follows: 828,662 fish were caught by 170,834 fishermen. Only 4% of the fishermen did not catch any fish, and each fishing party fished an average of 5.5 hours catching 16 fish. Seven percent of the fishermen live in the local community of the keys, Florida City, Homestead or Everglades City, Chockoloskee, while 87% live in the rest of Dade, Monroe, and Collier counties. The remaining 6% were split between the rest of Florida and out of state visitors. The relative fishing skills and experience of the fishermen varied considerably: 36% were classified as novices, 29% as skilled fishermen, 34% were family groups, and about 1% of the total fishermen were meat or food fishermen. Most of the fishermen (73%) did not try to catch any particular kind of fish. Red drum were the most popular fish specifically sought by 9% of the fishermen, next in popularity were snook (6%) and spotted trout (5%) followed by grey snapper (3%). Catch rate data which reflect fish abundance show that fish populations in the park are near their lowest levels for the last 15 years. A manuscript describing the data acquisition system and interpreting the data is in preparation.

# # #

COMMERCIAL FISHERY STUDY
EVER-N-54

INVESTIGATORS: Gary E. Davis)
Thomas W. Schmidt) National Park Service

SUMMARY OF PROGRESS: Catch and daily fishing effort are collected from reports submitted by guide and commercial fishermen monthly. These data are summarized by computer program developed with the National Park Service, Office of Systems Design, Washington, D.C. To date, the data processing portion of the program has been completed and data from fiscal years 1972 and 1973 have been completed; fiscal year 1974 is partially summarized. No trends have been identified in the fin fish populations. The stone crab fishery remains stable in terms of total harvest, however its catch per unit of fishing effort continued its alarming decline. The fishermen were forced to remove their traps from the water 6 weeks before the end of the open season due to lack of an economic return. In light of this situation it is imperative that we continue the management action of protecting female stone crabs in park waters.

# # #

WHITE IBIS FOOD ECOLOGY
EVER-N-59

INVESTIGATOR: James A. Kushlan
University of Miami and National Park Service

OBJECTIVES: To determine the adaptations of the White Ibis to the regional southern Florida environment and to study the ecological impact of the species in terms of prey consumption and energy requirements.

RESULTS: Southern Florida ibises consumed over 60 species of prey. Crayfish and fish were the two most important foods. Crayfish were highly selected. Fish were underrepresented in the diet compared to their availability. Food taken at various colonies differed but there was high similarity among freshwater colonies. Energy requirements for free existence were estimated to be 165 kcal/day, and the requirements for growth to fledging were 8620 kcal. It requires 2.9 X 10^4 kcal to support a family of ibises through the nesting season, and the southern Florida population is estimated to have consumed 2.9 X 10^9 kcal during the 1972 and 1973 nesting seasons, respectively.

Adaptations to the fluctuating water ecosystems of southern Florida include: intraregional migration; sequential utilization of the resources of the regional environment; wide prey acceptability but specialization on crustaceans; nomadism; movement of nesting locations in response to changing food conditions; prolonged nesting readiness; lowered fledging size; and intermittent nesting.

Publication

Kushlan, J. A. 1974. The ecology of the White Ibis in southern Florida, a regional study. Ph.D. Thesis. University of Miami, Coral Gables, Fl. 129 p.

# # #

SEA TURTLE ROOKERY STUDY
EVER-N-7

INVESTIGATOR: Gary E. Davis
National Park Service

SUMMARY OF PROGRESS: A manuscript detailing the work done on the Cape Sable loggerhead turtle rookery has been prepared and is in the review process.

# # #

BALD EAGLE STUDIES
EVER-N-9A

INVESTIGATOR: William B. Robertson, Jr.
National Park Service

SUMMARY OF PROGRESS: Work in CY 1974 was continued as in previous years, principally by Technician David Shea. Results included: (1) 50 pairs of Bald Eagles attempted nesting in the park and 28 young fledged from 19 successful nests, thus for the second year in a row productivity was well below the long-term mean; (2) intensive study of food remains from eagle nests resulted in identification of 34 pray items, mostly fish and birds; (3) systematic studies of the roosting aggregation of sub-adult eagles near Mahogany Hammock yielded considerable information on the behavior, feeding areas, flight lines, and age structure of this population segment.

# # #

CAPE SABLE SPARROW (*AMMOSPIZA MARITIMA MIRABILIS*), DISTRIBUTION, ECOLOGY, AND MANAGEMENT
EVER-N-28

INVESTIGATOR: Harold W. Werner

SUMMARY OF PROGRESS: During 1974 all previously known Cape Sable sparrow colonies were surveyed. Potential new sites were located on aerial photographs and surveyed by helicopter. The recently discovered population on Cape Sable could not be located, and the once large Big Cypress population appeared to be almost extirpated; however, the Taylor Slough population, which was previously known to occupy about 3000 acres, was extended to approximately 150,000 gross acres. Many areas could not be surveyed because of wildfires.

In the Taylor Slough area, a 372-acre area was established in which the ecology and life history of that population could be studied in detail. The Cape Sable sparrows within the area were banded and color marked. Data collected includes physical measurements of the habitat (biomass, density, height, hydroperiod, floral composition, etc.), sympatrics, migration, behavior, vocalizations, pair bond, territoriality, growth and development, predation, nest construction, incubation, reproductive rate and potential, nest defense, daily rhythm, molt, the effects of fire, etc.

Data collected since 1969 was compiled and organized from field notes.

# # #

FLORIDA BAY CROCODILE STUDY
EVER-N-26

INVESTIGATOR: John C. Ogden

SUMMARY OF PROGRESS: The major effort during calendar year 1974 was to make a final survey of active nests, and determine hatching success and factors affecting that success at each site. The correlated 4 years data on productivity, distribution, behavior, and habitat of these crocodiles will be used to prepare a report for publications.

During 1974 a management report which included suggestions for protection and management of Florida Bay crocodiles was prepared and submitted to the park personnel.

# # #

CONTROL OF EXOTIC PLANTS IN EVERGLADES NATIONAL PARK
EVER-N-18

INVESTIGATOR: Larry Bancroft
National Park Service

SUMMARY OF PROGRESS: *Casuarina:* Since the currently used techniques (fire and/or 2-4D) have proven very effective in the control of *Casuarina,* no further research in their control was conducted. However, current and former sites were resurveyed by air. These surveys have proven the need to occassionally retreat former sites.

Melaleuca: 2-4D appears to be effective in treating it; however more efficient and effective techniques are needed for the future when *Melaleuca* will probably become a serious problem in the park.

Schinus: The effects of treatment with either 2-4D or Cacodylic acid were generally marginal and very variable. Tests for an effective yet environmentally safe technique and/or herbicide will continue.

Colubrina anaticus: Aerial surveys showed that this exotic has invaded much of the high ground along the north side of Florida Bay and that it is displacing the native vegetation in hammocks and buttonwood scrub. 2-4D was effective, though not practical in killing it.

Other exotic plants: 2-4D was effective on *Ardina solanacea.* When 2-4D was used on *Pridium* and *Eichhornia* the effects were marginal, however these species do not as yet present serious problems.

# # #

WOOD STORK STUDIES
EVER-N-12

INVESTIGATOR: John C. Ogden

SUMMARY OF PROGRESS: This is a continuing study likely to go on for several more years. Major attention during calendar year 1974 was devoted to studies of food habits and feeding techniques of storks in various zones (mangrove, freshwater, etc.) of the park, related to seasons and surface water conditions. These data were used in various reports, including *The Food Habits and Nesting Success of Wood Storks in Everglades National Park in 1974*, by Ogden, J.A. Kushlan, and J.T. Tilmant. During 1974 a program of color-marking known-age storks in park rookeries was initiated as a means for learning some aspects of the species' nesting biology, and to determine seasonal and local movements of birds in Florida.

# # #

FLORIDA BAY OSPREY STUDY
EVER-N-9E

INVESTIGATOR: John C. Ogden

SUMMARY OF PROGRESS: The final year of study of Ospreys in Florida Bay was completed in May 1974. Data from this 7-year study will eventually be analyzed and prepared in reports for publication. One paper dealing with relationships between nesting Ospreys and Bald Eagles in Florida Bay was prepared in 1974, and will be provided to the park when final revisions are completed.

# # #

SOUTH FLORIDA BIRDS
EVER-N-8

INVESTIGATOR: William B. Robertson, Jr.
National Park Service

SUMMARY OF PROGRESS: I devoted 20 man-days in the fall of CY 1974 to preparation of a major paper, "The Southern Florida Avifauna," with J.A. Kushlan as an invited contribution to the symposium volume, *Environments of South Florida: Past and Present* (Miami Geological Society, Memoir No. 2, pages 414-452). Other time commitments in CY 1974 under the umbrella of this project included: (1) preparation of short publications on the 1973 nesting of Least Terns at Dry Tortugas (*Florida Field Naturalist*, 2:19) and the 1974 nestings of Brown Pelicans and House Sparrows at Dry Tortugas (*Florida Field Naturalist*, in press); (2) preparation of species accounts for 15 bird species (about 65 total typed pages) for the forthcoming book *Rare and Endangered Plants and Animals of Florida*; (3) referee's review and comment on about 25 manuscripts, mainly ornithological, sent to me by editors; (4) activities as President, Florida Ornithological Society, including conducting meetings at St. Petersburg in April and Gainesville in November; and (5) some progress in bringing Dry Tortugas bird record file up to date.

# # #

SHARK SLOUGH FISH PRODUCTION RELATED TO WOOD STORK NESTING SUCCESS
EVER-N-66

INVESTIGATORS: John C. Ogden)
James A. Kushlan) National Park Service

OBJECTIVES: To investigate the relation of surface water conditions in Everglades National Park to the feeding and nesting biology of Wood Storks with emphasis on the southern Everglades, known as the Shark River Slough.

RESULTS: Study this year concentrated on the nesting cycle of Wood Storks, relation of hydrologic conditions to Wood Stork nesting success, and food eaten by storks. Two thousand Wood Storks nested in late January and successfully reared 1900 young. This was the first successful nesting in Everglades National Park since 1967. An attempt to test a hypothesis that reduced discharge in November and December would increase drying rate and bring about earlier nesting was inconclusive. The timing of nesting however substantiated an empirically derived relation between nesting time and drying rate. Wood Storks fed where fish were relatively concentrated and moved to various feeding sites to utilize available prey. Storks consumed only a few species of fish and selectively consumed large fish. Some of the more abundant organisms available to storks were rarely consumed.

RECOMMENDATIONS: This study should be the first step in a comprehensive research program on the ecology of the Shark River Slough. Emphasis should be on the biology of the principal prey of wading birds, especially fresh water fish. Study of the Wood Stork should continue and research on other wading birds and the American alligator should be started in conjunction with hydrological research to determine the effect of surface water discharge on water levels and animal populations of the southern Everglades.

Publications

Ogden, J. C., J. A. Kushlan, and J. T. Tilmant. 1974. The food habits and nesting success of Wood Storks in Everglades National Park in 1974. Mimeo rept. U.S. Dept. Interior National Park Service. 95 p.

Ogden, J. C., J. A. Kushlan, and J. T. Tilmant, in press. Prey selectivity of Wood Storks. Submitted for publication.

# # #

SHARK SLOUGH STUDY (ESTUARY)

EVER-N-65

INVESTIGATOR: Gary E. Davis
National Park Service

SUMMARY OF PROGRESS: A large tropical estuary in Everglades National Park was studied to determine the effects of managing runoff into the headwaters of its watershed for a 12-year period. It was found that runoff as it affected water levels in the watershed played a major role in determining the seasonality and magnitude of salinity flux in the estuary and that because of the elevated mean salinities the estuarine nursery system was being replaced by a coastal marine complex. The destruction of the estuary was a result of changes in the seasonality of runoff, a slight decrease in mean annual rainfall over the watershed, and salt water intrusion through the Buttonwood Canal to the eastern end of the estuary. Management recommendations include closing the Buttonwood Canal and reestablishing the historical pulse runoff system to adequately feed and flush the estuary. Both actions to be accompanied by continued ecological monitoring.

# # #

ROUND-TAILED MUSKRAT (*NEOFIBER ALLENI*) STUDIES, EVERGLADES NATIONAL PARK

INVESTIGATOR: Jim Tilmant
National Park Service

SUMMARY OF PROGRESS: The round-tailed muskrat (*Neofiber alleni*) is a little studied microtine rodent of the Florida peninsula. It is particularly abundant within the Everglades and large areas of suitable habitat are protected by Everglades National Park. It is the objective of this study to obtain information on abundance, areas of occurrence, habitats utilized, effects of water conditions, and other unknown aspects of *Neofiber* life histories within the park.

During 1974, four *Neofiber* colonies were selected in varying environmental locations for close study and comparison. In addition, two colonies located in areas that were prescribed burned were observed. Vegetative plant communities in the immediate vicinity of the colonies were mapped and plant species composition, height, canopy coverage, and biomass determined. Evnironmental parameters such as water depths, temperature, soil type, and rainfall were recorded. On burned areas, short- and long-range effects on the colonies were observed and are to be correlated with plant regrowth and existing water levels. The number of houses located served as population indices for comparison of study areas.

The above studies centered in the Shark Valley Slough where *Neofiber* populations appeared to be the most abundant. However, general surveys and observations were made throughout the park to determine distribution patterns.

PLANS FOR 1975: Field work under the present project plans is complete. Data will be analyzed and reports of findings submitted.

# # #

REFORESTATION/RECLAMATION OF ABANDONED FARMLAND
EVER-N-61

INVESTIGATOR: William L. Bancroft
National Park Service

SUMMARY OF PROGRESS: The areas of former glade appear to be most effectively cleared with a bulldozer and rake followed by scarification, except on recently abandoned lands where disking is sufficient. Vary marginal success in restoring the cleared land to a prairie-type vegetation was obtained by transplanting *Andropogon* and *Spartina bakeri*, however the technique was not practical for a large operation. Some success was obtained by seeding sod master grass seed immediately after turning the soil and during the onset of the rainy season. The primary problem remains that the land once disturbed appears to succeed from former glade to herbs to native and exotic trees without passing through a stage which can be maintained as prairie with fire.

The areas of former pineland are also quickly invaded by native and exotic hardwoods, however the recently farmed areas appear to often pass through a grass stage which can be held at least temporarily by disking and/or burning at certain times during the year. Potted pine planted during the summer have given us our best initial survival (better than 90%). However the dense herbs, grasses, and woody plants cause the mortality to readily escalate. Bare root seedlings and seeded pine are cheaper but the survival is poor. In the future, pine will be planted in rows to allow mowing between rows to reduce their competition and to facilitate watering them.

# # #

WATER QUALITY ANALYSIS OF FLORIDA BAY
EVER-N-64

INVESTIGATOR: Thomas W. Schmidt
National Park Service

OBJECTIVES: To determine and evaluate hydrographic parameters of Florida Bay including salinity (ppt), temperature (C°), dissolved oxygen (mg/1), pH and turbidity (FTUs).

METHODS: A total of 38 water quality stations have been established throughout Florida Bay, those within biological study areas are sampled bi-monthly and the remainder are checked monthly. Measurements of most parameters have been made from May 1973 through December 1974.

RESULTS: Hypersaline conditions (above 40 ppt) have been recorded from most stations in central and eastern Florida Bay since March 1974. Northwestern Florida Bay salinities ranged periodically from estuarine to hypersaline conditions. Dissolved oxygen and pH readings remained high at most stations. Turbidity measurements were high at stations bordering the mainland and generally lower readings were recorded toward the Gulf waters. Since this project is still in progress no significant conclusions will be presented at this time. The work should proceed as planned.

# # #

FORT CAROLINE NATIONAL MEMORIAL

A SYSTEMS ANALYTIC APPROACH TO THE MANAGEMENT AND INTERPRETATION OF SPANISH POND

INVESTIGATORS: Larry D. Harris) University of Florida
Randy S. Kautz)

SUMMARY OF PROGRESS: Continuous measurements are currently being made of rainfall; runoff; water level; litterfall; nutrient content of rain in runoff and pond water; O_2; chemical oxygen demand; pH; temperature; and detritus dynamics. Water lily biomass has been sampled, and detritus has been sampled for decomposition rate studies. Winter photosynthetic rates are being determined employing infrared gas analysis techniques. Spanish Pond has been plane-table mapped for vegetation and a working draft is complete. Low-resolution aerial photographs of Spanish Pond are in hand; however, high-resolution aerial photos seem unavailable. Attempts to locate nearby meteorological data have been unsuccessful heretofore.

The only inputs, besides rainfall and runoff, into Spanish Pond appear to be a man-controlled artesian well and a culvert draining roadside ditches opposite the pond; however, it is felt that this culvert could be functional only during long periods of heavy rainfall. Evaporation, transpiration, and lateral seepage during dry periods are the only outlets from Spanish Pond. Water levels fluctuate seasonally with rainfall and influence the biota that may occur there. The layer of organic detritus covering the pond bottom leads us to believe that succession towards a terrestrial ecosystem is not occurring at a rapid rate.

To date, no fish have been observed in Spanish Pond; therefore, primary consumer populations include aquatic invertebrates which in turn support a host of secondary consumer populations including vertebrates as well as invertebrates.

Physical sampling of Spanish Pond should terminate around 31 December 1975. Unfortunately, personnel support funds run out August 1975. To remedy this discrepancy, additional funds may be requested for extended personnel support on graduate assistantship basis.

# # #

FORT JEFFERSON NATIONAL MONUMENT

TERN COLONY STUDIES

FOJE-N-2

INVESTIGATORS: William B. Robertson, Jr., National Park Service
G. E. Woolfenden, University of South Florida, Tampa

SUMMARY OF PROGRESS: Field studies at the tern colony in Cy 1974 involved 30 man-days by NPS personnel and 225 man-days by collaborators. Clerical work with project records totaled 12 man-days by the principal investigator and 78 man-days by collaborators, mainly the PI's wife. Work accomplished included: (1) 13,000 juvenile Sooty Terns and 700 juvenile Brown Noddies were banded; (2) 4700 previously banded adult Sooties were recaptured, the majority of these being birds of known age caught on eggs; (3) recaptures of individually color-banded Sooties showed that many nested in 1974 within 2 m of the place they nested in 1972 and that some pairs remained constant over a 2-year period; (4) blood samples were collected from 200 Sooty Terns and 150 Brown Noddies for study of tern colonies as a potential reservoir of human influenza virus (R. G. Webster, St. Jude's Children's Research Hospital, Memphis); (5) punch-card files covering about 100,000 recaptures of previously banded adult Sooty Terns were brought up to date with all data punched on the cards; (6) Harrington's study of Sooty Tern population structure, based in part upon work at Dry Tortugas, was published (*Bird-Banding* 45:115-144); and (7) significant progress was made with articles on movement of Sooty Terns from band recoveries and arrested molt of primaries in Sooty Terns.

# # #

SPINY LOBSTER STUDY

FOJE-N-6

INVESTIGATOR: Gary E. Davis

SUMMARY OF PROGRESS: The effects of sport harvest on a spiny lobster *Panulirus argus* population were studied at Fort Jefferson National Monument in Dry Tortugas, Florida from 1971 through 1974. For 29 months no harvest was allowed followed by 8 months of limited sport harvest (hand caught by divers). Data on the size, abundance, and natural history of the lobsters were collected by *in situ* observations using SCUBA and commercial trapping techniques. A total of 2207 *P. argus* was tagged and released. All 99 recaptured animals were recovered within 10 k of their release sites for periods of time ranging from 1 to 72 weeks, demonstrating the presence of the resident population. While an unharvested control area showed no difference in lobster size or abundance before and after the harvest period, the experimental area showed a 50% reduction in abundance after 8 months of harvest. Harvest of one-half the population could not be sustained by recruitment or growth without undesirable impairment of the lobster population. Management recommendations were made to prohibit further harvest until recovery to pre-harvest levels was attained. Additional harvest constraints were suggested. A professional paper entitled "Minimum size of mature spiny lobsters *Panulirus argus* at Dry Tortugas, Florida" was prepared and submitted to the American Fisheries Society for publication. An additional professional paper entitled "Effects of sport harvest on a spiny lobster *Panulirus argus* population" is in manuscript form. This paper details the work done for the past 3 years at Dry Tortugas and is intended to be submitted to the American Fisheries Society also.

# # #

FOSSIL BUTTE NATIONAL MONUMENT

A VEGETATIVE SURVEY OF FOSSIL BUTTE NATIONAL MONUMENT
KEMMERER, WYOMING

INVESTIGATORS: A. A. Beetle
C. B. Marlow

SUMMARY OF PROGRESS: A poorly developed soil profile and sparse, intermittent precipitation produces a harsh growing regime for plants in the Fossil Butte-Cundick Ridge area. Because of this, local plant communities are sharply delimited by edaphic and climatic conditions. The factor which most affects the area's vegetation is the amount of available soil moisture.

Generally, shrubs are better adapted for obtaining water during periods of intermittent precipitation and drought than grasses and forbs. Trees require large amounts of moisture daily. Because of these morphological characteristics, shrubs are more ideally suited for conditions prevailing on the monument. Consequently, shrubs and shrub communities dominate the vegetation types found on Fossil Butte and Cundick Ridge. The local geological formations have different water retention capabilities and these properties are reflected by the plants which occur on the respective formations.

Springs appear along the contact points between the Wasatch and Green River formations and to a certain extent along the contact points of the bull pen and Fossil Butte members of the Green River formation. The vegetation types which are characteristic of these contact points is the Aspen and Shrub Community. Moisture must be abundant and readily available for long periods of time in order for these communities to exist.

The soils derived from the quaternary deposits and Wasatch formation are tight and clayey. More water runs off these soils than is absorbed. The plants which inhabit these sites must be able to take up large amounts of water when it is abundant and reach deep water tables during periods of drought. Shrubs and related grass and forb species dominate these tight soil sites. Characteristic vegetation types are divided into two subtypes. Subtype 1--the dominant or most frequently occurring shrub, and other related shrubs. Subtype 2--the dominant or most frequently occurring shrub and related grass and forb species.

Subtype 1 predominates on ridges with southern and eastern exposures (these sites are relatively free of snow during the winter months) and on very steep ridges with thin, poorly developed soil profiles. Subtype 2 predominates in areas where the soil profile is more developed than those sites which subtype 1 inhabits and where moisture is not abundant enough to support trees or grass and forb communities but is more plentiful than on those sites on which subtype 1 occurs. Those communities which fit under the respective subtypes are:

Subtype 1 - Mountain Big Sagebrush and Shrubs
Shadscale Saltbush and Shrubs
Shadscale Saltbush and Alkali Sagebrush

Subtype 2 - Mountain Big Sagebrush and Grass

The angelo member of the Green River formation appears to produce a sandy clay soil. This soil type is better drained than those soils derived from the Quaternary and Wasatch formations. On Cundick Ridge the alkali sagebrush and grass community is restricted to those soils derived from this formation while on top of Fossil Butte the soils are derived from both the Angelo and Fossil Butte members of the Green River formation and here the alkali sagebrush and shrub community predominates.

Serviceberry, mountain-mahogany, mountain-mahogany and serviceberry, shadscale saltbush and shrubs, mixed shrubs, mixed timber and shrubs, and mixed timber communities occupy those sites on which soils are derived from the Fossil Butte member of the Green River formation. Mountain-mahogany, limber pine, and douglas fir occur only on this geologic member. The soil profile has a high pH and is poorly developed. Precipitation is not retained very well and water tables are almost non-existent. The mixed timber and mixed timber and shrubs exist on those sites where sonw accumulates during the winter months. Aspen and willow occur along the lower edges of this formation where the soil profile is better developed and more moisture accumulates. Mixed shrubs and serviceberry communities occupy draws and catchment basins on the Fossil Butte member while mountain-mahogany and shadscale saltbush and shrub communities occupy the driest sites. Scattered limber pines often inhabit some of the most barren and windswept slopes of the Fossil Butte formation. Douglas fir dominates north slopes and draws formed by this geologic feature.

The calcareous to saline soil gradient also dictates the plant species composition on Fossil Butte National Monument. However, soil pH is also dependent on precipitation. In heavy rainfall zones soils are acidic due to the leaching out of parent material. In the Great Basin, rainfall and runoff from winter snowmelt does not cause rapid enough leaching of soils to produce acidic conditions. The edaphic conditions of this region are as much a part of the climate as are the vegetation types. Ultimately the plant communities of Fossil Butte are delimited by the region's climate.

# # #

THE GEOLOGIC HISTORY OF FOSSIL BUTTE NATIONAL MONUMENT AND FOSSIL BASIN

INVESTIGATORS: Paul O. McGrew
Michael Casilliano

SUMMARY OF PROGRESS: Fifty million years ago the southwestern corner of what is now Wyoming was part of a system of three fresh-water lakes that covered that area plus adjacent parts of Colorado and Utah. Varying climatic and geologic conditions were responsible for changes in lake size and distribution. The waters of the lake teemed with fish. The forests along the shores were the homes for the ancestors of modern mammals. Today the history of the lakes and forests can be read in the thick sediments that were deposited long ago.

The complete geologic history of the Fossil Basin involves many stratigraphic units. Most of these are not exposed within the monument itself but are well known from outcrops outside the boundaries of the monument and from deep wells. Some 34 geologic formations are recognized in this section.

Stratigraphic units exposed in the park are described in the paper.

Fossils of plants, invertebrates, and vertebrates are abundant in the rocks exposed in the Fossil Basin.

The Eocene flora is quite similar to that now existing in southeastern United States, reflecting a warm and humid climate. The land animals indicate that a wide range of ecologic niches existed over the basin before the lake came into being, during its presence, and again all over the basin after the lake disappeared. Fossil Butte is most famous for the beautifully preserved fossil fish.

# # #

GLACIER BAY NATIONAL MONUMENT

SURVEY OF THE BIOTA AND ECOSYSTEMS OF GLACIER BAY NATIONAL MONUMENT
(GLBA-N-19)

INVESTIGATORS: G. P. Streveler
Monument Field Staff

OBJECTIVES: In general, to construct a "before" picture of the monument's biota and ecosystems against which man-induced changes can be measured. In particular this year, to continue and expand an ecological assessment of an area centering on Dixon Harbor along the monument's lower outer coast that may be disrupted in the near future by mining activity.

METHODS: See the 1972 report for a synopsis of methods applied to the general objective. Outer coast research by Streveler concentrated on mammals larger than mice. Methods consisted principally of general observation, extensive tracking, and scat analysis.

RESULTS AND CONCLUSIONS: As usual, the field staff contributed a wide variety of observations, principally upon birds and mammals. Organization of the bird record system neared completion. Work was begun on mounting herbarium specimens.

Outer coastal mammal research has led to these conclusions:

1. The larger mammal fauna consists of about 15 species, as compared to 27 for all of northern southeast Alaska.

2. Herbivores are particularly few in species; mustelids and ursids are fully represented.

3. Mountain goats and black bears are the most numerous large mammals.

4. Greatest mammal diversity and abundance is generally found along topographic and vegetational interfaces, as well as in certain key habitats such as marshes and the alpine.

5. Thoroughfare between valley systems is generally considerable, principally via coastwise trails.

6. Faunal relationships exist principally with the coastal lowlands to the northwest. The influence of postulated *refugia* in the Lituya Bay area on the study-area fauna remains unassessed.

7. Human alteration of the status quo may be most serious when it infringes upon herbivores, upon sensitive carnivores (cf wolf), or upon key localities along beaches, topographic breaks, in marshes and the apline.

PLANS FOR 1975: Studies next year will focus more intensively on key questions that have arisen in the course of the last 2 years, and on the heretofore little-studied fall season.

# # #

HARBOR SEAL MOVEMENTS, BEHAVIOR, ABUNDANCE
GLBA-N-13

INVESTIGATOR: G. P. Streveler

OBJECTIVES: To devise a census technique capable of detecting seasonal and annual changes in the abundance of Glacier Bay seals; to determine the impact of human intrusion into the Muir Inlet seal pupping area.

METHODS: A system involving coordinated land-based and aerial photographic counts is being field tested at Muir Inlet during the pupping season. Once successful there, it will be applied to other pupping areas within Glacier Bay in order to obtain summer population estimates. Censuses via boat, taken yearly, are providing comparative winter data. Observations on seal population structure, pupping behavior, inter- and intra-specific relationships, and response to boat and plane intrusion are made each year at Muir Inlet.

RESULTS AND DISCUSSION: In a comprehensive report of results to date, it is concluded that:

1. Aerial censusing efforts should be discontinued until more satisfactorily equipped aircraft are available; by contrast, surveys via boat and from shore have provided consistent and useful results.

2. Glacier Bay seals are divided into two populations, supported by recruitment from Muir and Johns Hopkins inlets, respectively.

3. The Muir population, and the composite Muir-Hopkins population pair, have apparently remained stable during 1973-74 and 1972-74, respectively.

4. The post-pupping Glacier Bay populations total approximately 3500 individuals, including about 700 pups.

5. At least 60% and probably 77% of these 3500 seals occupy Glacier Bay during summer. It is likely, but not yet demonstrated, that a more substantial proportion of the seals are absent from the Bay and the national monument during winter.

6. Pending further study, little seal mortality in Muir Inlet is due to human activity. That which may occur can be reduced by setting a limit on aircraft overflight elevations and on boat approaches to sleeping seals.

PLANS FOR 1975: The study will continue as in 1974, except that a several-day period will be spent attempting to accurately survey the Johns Hopkins population.

# # #

FOLLOW-UP ON SEA OTTER REINTRODUCTION
GLBA-N-12

INVESTIGATOR: G. P. Streveler

OBJECTIVES: To document the distribution and abundance of sea otters which were reintroduced into Glacier Bay National Monument in July 1968.

METHODS: Periodic spot checks along the monument's lower outer coast by plane and boat.

RESULTS AND DISCUSSION: This RSP has been deemphasized since 1973 for reasons explained in last year's report.

No definite sightings of sea otters in monument waters were made this year despite (1) considerable inshore boat survey work along the coast from Torch Bay to Palma Bay; (2) occasional boat surveys elsewhere between Taylor Bay and Lituya Bay; and (3) aerial reconnaissance of many coastlines in widespread localities.

PLANS FOR 1975: Surveillance by boat and plane will continue as the opportunity allows.

# # #

INTERTIDAL INVERTEBRATES OF DIXON HARBOR AND VICINITY GLACIER BAY, ALASKA

GLBA-N-19

INVESTIGATORS: A. R. Weisbrod, USNPS Cooperative Park Studies Unit
David O. Duggins, University of Washington

SUMMARY OF PROGRESS: Recent ecological research has shown that certain predators play particularly important roles in structuring communities (Paine, R. T. 1969. *Ecology* 50:950-961; Menge, B. A. 1972. *Ecol. Monogr.* 40:49-78). These "keystone" predators represent a point in the communities' trophic web where perturbations are likely to result in major changes when the predators populations are altered. For example, Paine (Paine, R. T. 1966. *Am. Nat.* 100:65-75) demonstrated that changes in the abundance of an intertidal starfish, *Pisaster ochraceus*, resulted in reorganization of the entire community of which it is a part. Experimental removal of *P. ochraceus* led to reduced spatial heterogeneity as the community became dominated by the California mussel *Mytilus californianus*. This species of mussel is competitively dominant to any other sessile members of the community and in the absence of its major source of mortality (*P. ochraceus*) it is capable of excluding most other species. The result is the formation of a solid homogeneous mussel bed.

The role of predation in structuring subtidal kelp bed communities is less clearly understood and is the area in which research will be conducted. This community is dominated by algae of the order Laminariales which includes the giant kelp common along the west coast of North America. These primary producers are grazed upon by a number of herbivores, the most important of which are urchins of the genus *Stronglocentrotus*. These urchins are in turn preyed upon by a number of vertebrate and invertebrate predators. Observations along the west coast of Washington (Mauzey, et al. 1968. *Ecology* 49:603-618) suggest that a major predator upon urchins is the large subtidal starfish, *Pycnapodia helianthoides*. If helianthoides is acting as a keystone predator, it does so by restricting the abundance of urchins and preventing the overgrowing of the kelp beds. Work done at Woods Hole Institute of Oceanography on the physiology of subtidal starfish (Blumer, et al. 1970. unpubl.) showed that small concentrations of crude petroleum (<10 μg/1) in sea water fouled the predators chemoreceptors and made detection of its prey items impossible. The study areas are located along a coastline where the potential for oil spillage is increasing, and we will be attempting to demonstrate the effects of such damage upon the community in question. We expect to find that such disturbance would lead to rapid growth of urchin populations. Paine and Vadas (1969. *Limnol. Oceanogr.* 14:710-719) demonstrated experimentally that increases in urchin density resulted in reduced algae diversity and eventually in the complete disappearance of algae populations. Palmanano (pers. comm.), studying the effects of the atomic bomb test at Amchitka, Alaska, reports that as a result of the subsequent death of sea otters (a major predator upon urchins locally), urchin populations increased such that within a year kelp beds were completely destroyed. Otters are generally rare along the coast of Alaska and British Columbia, and urchin populations are probably controlled by *Pycnapodia*. Kelp bed communities are economically important in that they serve as nurseries for commercially important organisms such as crab, shrimp, and herring and their maintenance is essential to the future of these industries.

We are examining the structure, demography, and dynamics of these subtidal communities in Dixon Harbor and vicinity (Glacier Bay, Alaska) with particular attention to the starfish, urchin, kelp interactions. Field experiments utilizing predator exclusion techniques will shed light on the exact role of *P. helianthoides*. Laboratory experiments will examine the effects of potential pollutants upon the feeding and reproductive biology of the major components of the system.

Hopefully, this study will contribute to existing ecological theories and provide the park administrators with the first comprehensive study of intertidal marine ecology undertaken in the monument. The information gained will provide baseline data from which to estimate the impact of the mining activities proposed for the immediate region of the study area and provide clues for potential ecological problems resulting from industrial pollution from both local mining activities as well as the potential oil tanker spills which may occur in the region.

# # #

BACKGROUND MARINE STUDIES IN THE PALMA BAY-DIXON HARBOR REGION

GLBA-N-19

INVESTIGATORS:
Howard Feder)
A. S. Naidu) University of Alaska
George Mueler)

SUMMARY OF PROGRESS: Biological Analysis. Seventy-five samples (nine samples from 1973 and sixty-six samples from 1974) have been analyzed for biota. Species composition, population density, and biomass studies have been completed and tabulated. Biologically Important Species (BIS) have been determined and their distributions plotted on maps of the area.

Geological Analysis. Twenty samples have been examined for organic carbon, carbonate, and size analysis, clay mineral analysis, X-ray diffraction analysis, and transition metals analysis and ERTS imagery studies are pending.

It should be understood that this study is preliminary and designed to contribute to the following goals. (1) Identification and location of the major infaunal species of the benthos in Dixon Harbor and Torch Bay. (2) Analysis of the geochemical parameters as well as transport and depositional processes in Dixon Harbor and Torch Bay. Expansion of this study to a program approximating that proposed in the research proposal IMS No. P73-74 presented to the National Park Service in December 1973 is necessary to develop an understanding of the geological and biological processes in the study area.

In addition, physical and chemical oceanographic studies are important, therefore the project should be expanded to include these studies as well.

# # #

GLACIAL GEOLOGY OF THE SOUTHWESTERN MARGIN OF THE BRADY GLACIER, GLACIER BAY NATIONAL MONUMENT, ALASKA

GLBA-N-19

INVESTIGATORS: Stephen J. Derksen) Ohio State University
Richard P. Goldthwait)

SUMMARY OF PROGRESS: Field work done in 1974 indicates that during Late Wisconsin time the Brady Glacier almost entirely overwhelmed the low mountains on either side of its margins and formed a vast piedmont lobe along the coast between Icy Point and Cape Spencer. This ice had greatly receded by about 11,000 B.P. or earlier when an extensive marine platform was cut into the isistatically depressed landscape. As the land rose following deglaciation the sea receded and a thick sequence of gravels was deposited in valleys marginal to the ice. From about 1740 to 1440 B.P. the Brady advanced dramatically over this gravel and (1) built the outermost moraine in the Palma Valley; (2) built a complex of moraines in the upper Boussole Valley that dammed Boussole Lake; (3) deposited terminal moraines near the mouth of the Dixon River; and (4) built the high moraine which dams South Deception Lake. The ice then receded but has remained fairly near its present position since 1794.

PLANS FOR 1975: First, field work in critical areas of terminal and lateral moraines in Taylor Bay in order to extend the chronology worked out for the eastern margin of the ice to the main terminal area of the glacier. Second, marginal areas around the Deception Lobe that were not visited in 1974 need to be examined for careful tree-ring dating of several minor advances of the ice over the past century. Third, ancient mountain hemlocks growing at high elevations should be examined for a possible climatic history stretching back over the past few centuries. Fourth, higher levels of several dumping lakes should be dated by a tree-ring technique.

# # #

DIXON HARBOR BIOLOGICAL SURVEY

GLBA-N-19

INVESTIGATOR: Edmond Ernest Murrell

SUMMARY OF PROGRESS: The identification of all fish caught during the summer sampling period, June-August, is completed. All the fish caught were typical, known species of the region.

Future freshwater fish work should concentrate on the different drainage systems separately A knowledge of the size and occurrence of the different spawning runs is sorely needed for each drainage. A more complete identification of the different species of fish in each drainage should be conducted. Finally, an estimation of the population size, where possible, of the native fish species would be valuable. To accomplish this, a longer field season, from June-November, would be needed. More equipment, such as nets, weirs, boats, tents, etc., would have to be furnished along with additional salary for the increased field time.

# # #

SOME STUDIES OF *CORNUS* AND *SPHAGNUM* AT GLACIER BAY NATIONAL MONUMENT
GLBA-N-9

INVESTIGATOR: Mark G. Noble
University of Minnesota, St. Paul

SUMMARY OF PROGRESS: Field Station A - Torch Bay. This station served as a collection site for *Cornus canadensis* L., *Cornus suecica* L., and *Cornus canadensis* L. x *suecica* L.

The *Cornus* collections made here were dried and shipped to the University of Minnesota herbarium. Several live specimens were also collected and shipped to the University of Minnesota greenhouses for cultivation. Approximately 15% of all transplantations have been successful. A reconnaissance of the habitat of the *Cornus* plants was made and familiarization with the local flora started. Habitat photographs were taken.

Field Station B - Bartlett Cove. At this site collections of *C. canadensis* were made, and many clones were extensively excavated, dried, and shipped to the University of Minnesota herbarium. Again, live specimens were also collected and shipped to the University of Minnesota greenhouses for cultivation. *Cornus suecica* and *C. canadensis* x *suecica* were not found at this location.

Extensive collections of the forest associates of *C. canadensis* were made, dried, and shipped to the University of Minnesota herbarium. Habitat photographs were taken.

Patches of forest mosses were apparently increasing in importance in this area of *Picea sitchensis* (Bong.) Carr. (Sitka spruce) forest. This forest has been developing since the ice retreated from the area approximately 200 years ago. Twelve permanent plots of mosses were established, mapped, and photographed. Voucher specimens have been deposited in the University of Minnesota herbarium.

Four permanent plots of *Sphagnum* were established, mapped, and photographed. One permanent plot was established with permanent height-measuring markers across a transect; the measurements taken will allow future studies to determine the rate of vertical growth of the *Sphagnum* plants.

Field Station C - Pleasant Island. Collections of *Cornus canadensis, C. suecica,* and *C. canadensis* x *suecica* were made at this site, as were habitat studies and photographs. Collections of bog and forest associates were made. Many of the collections of *C. suecica* were in fruit.

Photographs were taken of *Sphagnum* patches growing out into the ponds of the numerous slope fens on the island.

Field Station D - Muir Point. The purpose of occupying this station was to search for the age of developing forest in which *Cornus* first appears. Unlike the sitka spruce forest of Bartlett Cove (Field Station B), the forest here consists of an extensive alder thicket with mostly scattered and isolated Sitka spruce. Muir Glacier was near this location in 1892, making this forest considerably younger than that at Bartlett Cove.

No *Cornus* specimens were found. Extensive collections from this forest were made.

SIGNIFICANT FINDINGS: 1. While *Cornus suecica* was found only in slope fens, *C. canadensis* and *C. canadensis* x *suecica* are found in many Sitka spruce areas and also in many of the slope fens. No substantial sorting of *C. canadensis* and *C. canadensis* x *suecica* into different habitats was observed.

2. All three *Cornus* types were seen in fruit, at least to some degree, and all three propagate by underground rhizomes. This latter characteristic is most pronounced in *C. canadensis* and *C. canadensis* x *suecica*.

3. Prior to this study one *Sphagnum* patch was known to be developing in the 200 year-old forest at Bartlett Cove (Field Station B). Four additional patches were located in this forest and were made into permanent plots. Additional areas of extensive *Sphagnum* growth were located in pond areas four miles north of the permanent plots of Field Station B.

4. Though the vegetation of the forest floor beneath the Sitka spruce now developing in the alder thicket at Muir Point (Field Station D) includes a few of the species of *Cornus* associates found at Bartlett Cove, no *Cornus* has appeared at this successional stage.

RECOMMENDATIONS: 1. Herbarium specimens of *Cornus canadensis, C. suecica,* and *C. canadensis* x *suecica* have been received or requested from: The National Museum of Canada, The Gray Herbarium, The University of Colorado, The Museum of Natural History, Stockholm. These specimens will be carefully studied, along with the material collected at Glacier Bay National Monument, to help elucidate the taxonomy of *Cornus canadensis* x *suecica.* Leaf shapes, numbers, and positions as well as flower and fruit characteristics will be compared, and a check for abortive pollen will be made from the supposed hybrid specimens.

2. Identification of the extensive collections made of the forest associates of *Cornus* will be continued. This is currently approximately 40% completed.

3. Identification of the collections made at Muir Point (Field Station D) will be continued. This is approximately 65% completed.

4. The portions of the *Sphagnum* patches established need to be remapped, height measurements taken again, and should be rephotographed in the future to determine their actual rate of growth and to ascertain their importance in the paludification of the forest.

5. Extensive collections should be made repeatedly at Muir Point (Field Station D). These should be coupled with return trips aimed at finding when *Cornus* first appears in the successional sequence at Glacier Bay National Monument.

# # #

IDENTIFICATION & CATALOGING OF VARIOUS CETACEA ON AN INDIVIDUAL BASIS, AND THEIR GENERAL MOVEMENTS WITHIN THE MONUMENT

GLBA-I-2

INVESTIGATORS:
Charles M. Jurasz
Virginia Jurasz
Susan Jurasz
Peter Jurasz

SUMMARY OF PROGRESS: Work was done in previous years without the support of the NPS. Via long time periods and photographic records various Cetacea, including and most commonly the humpback, *Megoptera novaeanglia*, are identified and cataloged on an individual basis. A record of their occurrence, location, and activity and the duration of the observations has been kept.

The number of animals frequenting the monument's waters is significantly smaller than the number indicated by the consessioners' and naturalists' sightings logs. Certain individual animals frequent specific locales during certain times of the year. These areas are frequented by the same individuals for time periods approaching one month in duration. The animals use specific feeding patterns in specific locales. There are pronounced changes in the behavior of some humpbacks as they are approached or as they approach large vessels (i.e., tour vessels), e.g., change in direction of travel, in distribution within the monument, and from one type of activity to another such as from feeding to traveling.

# # #

GLACIAL GEOLOGY OF NORTHWESTERN FJORDS OF GLACIER BAY NATIONAL MONUMENT, ALASKA

GLBA-I-3

INVESTIGATORS: George M. Haselton, and student assistants
Clemson University, Clemson, S. C.

SUMMARY OF PROGRESS: To date we have completed a wildlife survey for the National Wildlife Federation and examined about one-half of the important stratigraphic exposures. Much work needs to be done south of Johns Hopkins Inlet and the summer of 1975 (if funds are available) we plan to concentrate in those areas where only initial investigations were carried on last year. Thorough sampling of stratigraphic units needs to be completed. We plan to collect critical organic materials for C-14 dating to delimit the late Wisconsin and Neoglacial boundaries. Also we will collect more photographic data from Dr. Fields, Am. Geog. Soc. photo stations for comparative changes in Margerie and Grand Pacific glaciers. Examinations of wave cut and uplifted benches and ice-contact forms now building.

Of significance are the surge-waves on Margerie and Grand Pacific glaciers.

# # #

SMALL MAMMAL POPULATIONS IN THE DIXON HARBOR AREA

GLBA-N-19

INVESTIGATOR: Carol J. Terry
University of Kansas

SUMMARY OF PROGRESS: At this time we have data for 2 summers on the small mammal populations in Dixon Harbor and surrounding areas. These represent a high and low in the population cycles of these animals. A species list of the small mammals present has also been compiled and a rough estimate of abundances has been made. Enough is known about the area to realize that it is a unique one.

Species of *Microtus* and *Clethrionomys* coexist in many habitats. They are known to be mutually exclusive in other areas (eastern Canada and central United States). *Clethrionomys rutilus* populations are cyclic. They are not cyclic in other regions of Alaska. *Sorex cinereus* may be influenced by abundance of *Sorex obscurus*. Anomalies occur in the cheek teeth of *Microtus longicaudus*. These are genetically controlled and may represent ecological adaptations. Populations of *Microtus longicaudus* and *Clethrionomys rutilus* fluctuate drastically.

RECOMMENDATIONS: Research on the small mammals of this area should be continued for at least 3 years to determine the course of the microtine cycles. The extremes have been established but we have no indication of what the normal or average situation is if one exists. The interactions of the animals and vegetation should be investigated, particularly those of the microtine because of their extreme fluctuations. The affect of the mouse population on plant communities should be determined. A unique ecological system exists in this area with few small mammal species present. The effects of the introduction of possible competitors should be investigated.

# # #

DIXON HARBOR BIOLOGICAL SURVEY--VEGETATION ANALYSIS AND ENVIRONMENTAL STUDIES AT THE GRANDUC MINE, STEWART, B.C.

GLBA-N-19

INVESTIGATOR: Ian A. Worley
The University of Vermont, Burlington

SUMMARY OF PROGRESS: Releve sampling of plant communities in the Dixon Harbor area consisted of 113 forest samples, 54 shrubland samples, 44 tidal meadow samples, and 22 peatland samples. These samples essentially complete the lowland community sampling except for successional communities on outwash and freshwater marshes. Analysis of these data now underway permits characterization of the communities and the subcommunities (where they exist).

A report of the Granduc investigations is now being circulated within the NPS. Conclusions reached from the Granduc Mine visitation indicate that the physical problems of mining in the Dixon Harbor-Brady Glacier area are the easiest to overcome; more difficult are the ecological-environmental; *most* difficult (from both the mine company's and the National Park Service's viewpoints) will be the sociological problems, and the kick back of the sociological problems severely affects the ecological-environmental.

The vegetation analysis should be expanded to include outwash successional stages, freshwater marshes and alpine communities. That will conclude the phyto-sociological work; ecosystem studies (e.g., energetics, productivity, biomass, etc.) are yet to come in a following study at an undetermined time. Another visit to the Granduc Mine does not seem required at this time. However, sociological studies of remote mining communities seem desparately needed in the threat of actual mining in Glacier Bay National Monument.

# # #

AN ORNITHOLOGICAL SURVEY OF THE DIXON HARBOR AREA, OUTER COAST, GLACIER BAY NATIONAL MONUMENT

GLBA-N-16

INVESTIGATORS: Sam Patten) The Johns Hopkins University, Baltimore, Md.
Renee Patten)

SUMMARY OF PROGRESS: There were 11 orders of birds with 88 species in the Dixon Harbor area, Glacier Bay National Monument, SE Alaska, during the 1974 field investigation (14 May - 4 August). Passeriformes, Charadriformes, and Anseriformes were the most widely represented orders. Finches, Sandpipers, and Diving Ducks were the most widely represented families. The Black-legged Kittiwake was the most commonly observed species. Information indices comparing the data gathered by Gorden in 1973 and the data gathered in 1974 by the above investigators showed little difference in overall avian community structure, thus establishing a 2-year baseline for future comparative studies. Each of 15 avian habitats ranging from offshore waters to alpine conditions was characterized verbally in a written report submitted in January 1975. The eight most important avian habitats were analyzed quantitatively using Brillouin's formula. Hemlock and spruce (cedar) forests were the most diverse avian habitat due to high equitability of species, and the cliffs and gullies of Boussole Head were the least diverse habitat due to concentration of numbers into just a few species. Maximum richness of bird species (highest numbers) was observed in coastal waters. The Palma Valley was the most diverse geographical area from an avian standpoint, and Boussole Head was the least diverse. This indicates that the north side of the Astrolabe Peninsula and the SSW side of Boussole Head, containing the largest concentrations of nesting seabirds in the study area, were the least stable and hence most vulnerable areas examined in the summer of 1974. The 1974 inspections enabled a rough outline of the Black-legged Kittiwake reproductive cycle to be drawn up. About 400 pairs of Kittiwakes breed in four sub-colonies in caves and on exposed cliff faces at the tip of Boussole Head. Kittiwakes began nest-building in early June and fledged some young by the end of July. Since the Boussole Head seabird colony is the least diverse avian habitat and the least diverse geographical area analyzed, it is the most susceptible to perturbation. It is suggested that this colony be examined further to provide baseline data.

# # #

A MARINE MAMMAL SURVEY OF THE DIXON HARBOR AREA, OUTER COAST, GLACIER BAY NATIONAL MONUMENT, SE ALASKA

GLBA-N-19

INVESTIGATORS: Renee Patten)
Sam Patten) The Johns Hopkins University, Baltimore, Md.

SUMMARY OF PROGRESS: Six species of marine mammals were observed in the Dixon Harbor area, SE outer coast, Glacier Bay National Monument, during the investigation time (28 May to 4 August 1974).

	Species	Estimated Numbers	Number of Observations
1.	Harbor Seal	60	160
2.	Steller's Sea Lion	11	44
3.	Harbor Porpoise	9	20
4.	Dall Porpoise	1	1
5.	Killer Whale	4	10
6.	Humpback Whale	3	4
TOTAL 6	Species	85 animals	239 observations

Harbor Seals were concentrated in the Dixon Harbor area and on the NW side of Boussole Peninsula. Sightings of very small animals suggest pupping grounds in the area. Harbor Seals enter the Dixon River to take advantage of fish runs (Osmeridae?). Steller's Sea Lions were concentrated on offshore rocks on the SW side of Sugarloaf Island. A large male was often accompanied by a group of smaller animals, presumably females or immature males. Eleven animals were seen at one time on rocks near Sugarloaf. Other sightings were off the entrance to Torch Bay, Boussole Head, and Astrolabe Peninsula. The large male is a conspicuous animal often sunning on large rocks. He does not flush easily but gives harmless threat displays. He is susceptible to being shot by fishermen.

Harbor Porpoises were seen in small groups in Torch Bay, Dixon Harbor, and off Boussole Head. They apparently concentrated where fish were available.

A solitary Dall Porpoise was observed once just inside the entrance to Dixon Harbor, in juxtaposition to a scattered group of apparently feeding Harbor seals and Harbor Porpoises. Behavior was quite different from the usually observed Harbor Porpoises--high speed, planing at the surface. Groups of three Killer Whales were seen off Sugarloaf Island and inside the entrance to Torch Bay several times during the summer. These are very active and wide-ranging animals and are by no means confined to the Dixon Harbor area. A solitary female was seen some hundreds of meters off Palma Beach in early August, apparently in hunting behavior. Humpback Whales were seen off the entrance to Torch Bay several times through the summer. Their passage up and down the Outer Coast of Glacier Bay National Monument is probably a regular occurrence.

# # #

POPULATION BIOLOGY OF MARINE AVIFAUNA OF GLACIER BAY
GLBA-N-16

INVESTIGATORS: A. R. Weisbrod, USNPS Cooperative Park Studies Unit
Samuel M. Pattern, Jr., University of Washington

SUMMARY OF PROGRESS: North Marble Island lies in the middle of Glacier Bay and contains large marine bird colonies. About 500 pairs of gulls nest in the sloping meadows on North Marble; the rest of the island is covered with Sitka spruce. Two species, the Herring Gull and the Glaucous-winged Gull, breed sympatrically on North Marble, with some interbreeding; the Glaucous-winged Gulls far outnumber the Herring Gulls. The reproductive biology of these two species was examined in the field seasons of 1972 and 1973, from samples of 160 to 290 nests.

Gull territory size averaged about 18 m^2 but varied from colony to colony. Larger colonies had smaller mean territory size, and vice versa. Gulls used extensive amounts of vegetation for nest construction; moss and grass were the principal nest components. Nests averaged 22 X 22 cm across the inside and 38 X 38 cm across the outside, and averaged 10 cm deep. Egg-laying was late May to early June; average clutch size was nearly three. Incubation took about 3.5 weeks; hatching success was high in spite of about 25% egg loss to predators, mostly gulls. Very few eggs (other than those predated) failed to hatch; there were no signs of eggshell weakness. Most chick mortality occurred soon after hatching, due to attacks from other adult gulls. Older chicks wandered extensively towards the end of breeding season. Fledging took about 40-45 days, and overall success was quite good, averaging about 1.77 chicks fledged per nest per year, or 61% fledging success. This high reproductive rate could account for colonization of recently deglaciated areas around Glacier Bay. Gulls are influencing vegetation structure and soil conditions in the areas in which they nest, and gulls could be influenced in turn by encroaching forest which makes colony sites untenable.

This study indicates a pioneering gull population reproducing well under "wild" conditions in post-glacial surroundings. It is concluded that the gulls in Glacier Bay are exploiting an unfilled niche, and predicted that the gulls will continue to reproduce well under these conditions.

Publication

1974. Sympatry and interbreeding of Herring and Glaucous-winged Gulls in southeastern Alaska. *Condor* 75:343-344.

# # #

PRELIMINARY INVESTIGATIONS OF THE LITUYA BAY ICE-FREE REGIONS
GLBA-N-17

INVESTIGATOR: A. R. Weisbrod
USNPS Cooperative Park Studies Unit, University of Washington

SUMMARY OF PROGRESS: The third trip into the Echo Creek drainage, 10 km NW of Lituya Bay (50 42'N, 137 40'W) was undertaken between 3-8 July 1974. A base camp was established at Gold Western, Inc.'s Echo Creek Mining Camp on the mouth of the creek. The forest to the east of the camp is composed largely of Sitka spruce and what seemed to be an uncomfortable mixture of devel's club and salmon berry. To the east of the camp a wide sandy beach of several hundred meters in width meets the sea. Moose, wolves, and grizzly bears foraged daily along the beach and creek during my stay. A flock of 23 whimbrels was seen on 7 July at the mouth of Echo Creek, and a pair of trumpeter swans was encountered resting on the creek's quiet waters on several occasions.

My main activity dealt with sampling several transects placed through Gold Western's Placer Claims Nos. 3, 4, 11, 12.

Gold Western's Placer Claims Nos. 3, 4, 11, 12 in the vicinity of the base camp were located and transects were established on the claims to sample both the small mammals and vegetation of the area. A total of five, *Clethrionomys rutilus* were taken giving a catch/effort figure of 1.3. Last season's figure on the same transects was 4.8. Similar low catch/effort results were obtained by other workers in the Dixon Harbor region on these same dates, suggesting that the microtine population of the monument's outer coast was experiencing a population decline characteristic of these rodents. If Gold Western indeed intends to activate its Placer Claims in the near future then considerably greater effort should be expended in the region to ascertain the potential impact of their proposed Placer mining.

# # #

HABITAT SELECTION IN THE GENUS *JUNCO*

INVESTIGATOR: John R. Haldeman
Florida Southern College, Lakeland

SUMMARY OF PROGRESS: Phase I of the project has been completed and a copy of the report will be forthcoming in May. The habitat necessary for *Junco* territories has been computer analyzed. A comparison of North Rim habitats to South Rim habitats is continuing.

Phase II on distribution and movements of birds within the canyon will be completed by the end of 1975. The avian report on observations from Shiva Temple is soon to be published.

# # #

ECOLOGY OF THE KAIBAB SQUIRREL

INVESTIGATOR: Joseph G. Hall
San Francisco State University

SUMMARY OF PROGRESS: I arrived on the North Rim on 18 June and remained until 5 July. The primary accomplishment of this season's work was to rerun the vegetative plots scattered over what is thought to be good squirrel habitat in order to estimate the current status of the population. These plots had not been run in 1973 when I was out of the country, the first gap since this system was initiated in 1960. Since I do not plan to continue to run these plots in the future, I made special efforts to improve the visibility and permanence of the plot markers so that future biologists, presumably NPS personnel, could carry on without a loss in continuity. John Ray, NPS ranger on the North Rim, was particularly helpful and accompanied me on several runs. The results of this year's tallies were alarming, the density of squirrel sign being by far the lowest since the modified tally method was adopted in 1970. Comparative densities, expressed as number of clippings per acre, are listed below:

1970:171 1971:110 1972:20 1973:no data 1974:11

Squirrels, as evidenced by sightings, were virtually nonexistent in the park this summer. I estimate there were less than 100 individuals constituting the park population.

Luckily, the density within the national forest north of the park seemed considerably higher but, even there, it was far below that of recent years and cause for much concern. Because of the very low level of the squirrel population I decided any attempts to obtain more data on summer home ranges would be fruitless. I did obtain some more twig samples for analysis. Results are not yet available. In August I worked in cooperation with NFS personnel at Jacob Lake.

# # #

VEGETATION CHANGES IN THE GRAND CANYON

INVESTIGATOR: Raymond M. Turner

SUMMARY OF PROGRESS: Martin M. Karpiscak (Museum of Northern Arizona) and I have been working together on this project and plan to begin writing a manuscript shortly. The work should be completed by the end of 1975.

# # #

FLUVIAL MORPHOLOGY OF THE COLORADO RIVER THROUGH THE GRAND CANYON AS AFFECTED BY THE RESERVOIR BEHIND GLEN CANYON DAM

INVESTIGATORS: E. M. Laursen)
S. Ince) University of Arizona, Tucson

SUMMARY OF PROGRESS: Two years ago E. M. Laursen and S. Ince of the Department of Civil Engineering of the University of Arizona began a study of the fluvial morphology of the Colorado River through the Grand Canyon as affected by the reservoir behind Glen Canyon Dam. The initial phase of the study resulted in an estimation that the controlled river had a capacity to transport about 13 million tons of beach building sediment in an average year, but that only 3 million tons were supplied to the river from the tributaries below Glen Canyon Dam. As a result the necessary sediment would tend to be picked up from the bed and beaches of the river with a gradual depletion of the available sediment. The characteristics of a pool-rapid river was the second phase of the study. In a series of pools separated by rapids, changes in discharge give rise to scour or fill in the pools starting at the head end of the pools; the hydraulic characteristics of the controls at the rapids and of the pools determining whether the result is scour or fill and how much. The purpose of the trip through the Colorado River this past summer was to obtain some measurements of width, depth, velocity and slope in typical pool reaches of the Grand Canyon section of the river. Hopefully, these measurements will permit application of the generalized study to the particular geometry of the Colorado and, thereby, give greater insight into the past, present, and future behavior of the Colorado.

# # #

RIVER CONTACT STUDY

INVESTIGATORS: J. Eugene Haas)
Joyce M. Nielsen) Human Ecology Research Services, Boulder, Colorado
Byron B. Shelby)

SUMMARY OF PROGRESS: The period from April through 30 September 1974 was spent developing measurement instruments, perfecting data gathering techniques in the field, and consulting with Park Service personnel. We will emerge from this period with a design tailored to Park Service information needs, the data necessary to develop concise and reliable research instruments, and the experience necessary for a smooth and comprehensive effort in the field during the summer of 1975.

A data collection procedure was developed in which participant-observers were to accompany a sample of river trips, record contact data, make extensive observations of the trip as a whole, and at the end of the trip, elicit user responses via a self-administered questionnaire.

The observers kept records of (1) all contacts with other parties while on the river; (2) intra-group social interaction processes; and (3) weather and river conditions. In addition, diaries kept by the observers contained more detailed and extensive information about the social qualities and overall pattern of the trip.

The sample of 11 trips taken yielded 213 individual responses and approximately 117 river days of observation data.

# # #

GRAND CANYON ARCHEOLOGY

INVESTIGATOR: Douglas W. Schwartz
School of American Research, Santa Fe, New Mexico

SUMMARY OF PROGRESS: Unkar Delta Project. The School of American Research conducted field work in the Unkar Delta region of Grand Canyon National Park in 1967, 1968, and in 1970 completed an intensive inventory survey of the delta. A preliminary report was published in 1970 and work on a final monograph is now 85% complete.

Bright Angel Canyon. Excavation of a settlement located in Bright Angel Canyon was carried out by the school in the summer of 1969. A preliminary report was published in 1970 and work on publication of a final monograph is now 85% complete.

Walhalla Plateau survey and excavation. In 1969 and 1970 the school intensively surveyed the Walhalla Plateau. In addition, several sites located in the survey were tested and a number of sites were completely excavated. A preliminary report was published in 1969. In addition, a report was presented in 1971 to the Grand Canyon National History Association. Work on the final monograph is now 85% complete.

Grand Canyon Overview. Jim Walker of the school's archaeological research staff has recently completed an overview of all archaeological work done in Grand Canyon National Park to date (NPS contract # CX800030032). A final draft has been submitted to the Arizona Archaeological Center and has been returned with comments and suggested revisions. Those revisions are currently being incorporated.

Grand Canyon Synthesis Project. (NPS grant # CX800030026) Progress has been made on this report during 1974. It is anticipated that the project will be 25% complete by the end of the year.

# # #

AIR POLLUTION DETECTION BY LASER BEAM

INVESTIGATOR: Richard G. Layton
Northern Arizona University, Flagstaff

SUMMARY OF PROGRESS: The laser system has been used intermittently during the year making spot measurements about once a month. In comparing the laser results with other methods used by other investigators at locations other than the Grand Canyon, we have noted a consistent low result from the laser. Alternate methods of measuring visibility are being compared at the times laser measurements are done at the Grand Canyon. Because these other measurements require cloudless days for them to be correct, only a few good measurements have been made. It does appear that the laser which has been giving visible ranges averaging 100 km should be averaging about 200 km. This means that the canyon air is cleaner than we have previously reported, and as of now there does not appear to be any degradation of it.

A large collector for the laser is being obtained and within the next 6 months we plan to have the laser calibrated and back in continuous operation. We also have a blue laser and intend to do spot measurements using this laser during the next year.

# # #

PRECAMBRIAN PALEOMAGNETIC STUDY OF DIKES AND SILLS

INVESTIGATOR: Edwin Larsen
University of Colorado, Boulder

SUMMARY OF PROGRESS: We have finished our study of Precambrian intrusive rocks in Grand Canyon (in and near Rat Canyon) and find a paleomagnetic pole for these rocks at 0° latitude, 185W longitude. This position is approximately what one would expect for rocks about 1 b.y. old.

We dated a sample from one of the sills and obtained a K-Ar age of 850 m.y. It would appear that the sample has lost Ar and that the age is younger than it should be.

# # #

ARIZONA LICHEN FLORA

INVESTIGATOR: Thomas H. Nash, III

SUMMARY OF PROGRESS: My long-term project involves working on a lichen flora for Arizona. Collecting was initiated 4 years ago and will continue for another 2 or 3 years.

As a portion of the overall project I have been collecting within the Grand Canyon National Park. In this capacity I have now collected at several locations along the south rim, near the Kaibab Trail, along the Colorado River (while on a raft trip this summer), and at three locations along the north rim. Although I would like to collect on the north side again, I believe that I've made a reasonably representative collection at this time.

Although all the specimens are not curated and identified at this time, a preliminary list of species is tabulated below. A more complete list will be submitted at a later time along with specimens which are available in duplicate.

LICHENS OF GRAND CANYON NATIONAL PARK

Usnea cavernosa
Ramalina siensis
Staurothele clopima
Caloplaca trachyphylla
Caloplaca murorum
Caloplaca arizonica
Xanthoria elegans
Candelariella aurella
Candelariella rosulans
Candelariella deflexa
Parmelia lineola
Acarospora scheicheri
Acarospora strigata
Acarospora fuscata
Lecanora garovaglii
Collema polycarpon
Rhizocarpon disporum
Lecanora melanophthalma
Lecidella stigmatea
Lecanora alphoplaca
Caloplaca decipiens
Lecidea tessellata
Physcia caesia
Lecanora dispersa
Toninia caeruleonigricans
Lecidea russellii
Xanthoria fallax
Xanthoria polycarpa
Parmelia mexicana
Parmelia subolivacea
Parmelia substygia
Lecanora chrysoleuca
Lecanora novomexicana
Thyrea pulvinata
Dermatocarpon leptophyllum
Dermatocarpon lachreum
Dermatocarpon miniatum
Dermatocarpon plumbeum
Dinieleana oriena
Lecanora muralis
Lecanera frustulosa
Diploschistes scruposus
Physconia muscigena
Lecidea crufonigra
Physcia orbicularis
Cladonia pyxidata
Lepraria memsranacea
Cladonia cariosa
Lecanora cenisea
Phizocarpon riparium
Lecidea atrobrunnea
Nephroma parile
Psoroma hypnorum
Usnea hirta
Squamarina lentigera
Lecidea diecipiens
Fulgensia desertorum

# # #

CHROMOSOME VARIATION IN NORTH AMERICAN FENCE LIZARDS (GENUS *SCELOPORUS; UNDULATUS* SPECIES GROUP)

INVESTIGATOR: Charles J. Cole
American Museum of Natural History, New York,

SUMMARY OF PROGRESS: My research on chromosomes, variation, and geographical and ecological distribution of the fence lizard, *Sceloporus undulatus*, is continuing (see reports of 18 December 1972 and 5 December 1973). Data now on hand indicate that I have gathered sufficient field samples from Grand Canyon National Park for completion of this project, but I cannot be certain until all data analyses are finished.

Sceloporus undulatus elongatus (North Rim) and *Sceloporus undulatus tristichus* (South Rim) are distinctly different subspeices in terms of their external morphology and habitats, but the karyotypes of their populations inhabiting the opposite sides of the Grand Canyon appear to be indistinguishable. At other localities in Arizona, these subspecies have distinctly different karyotypes (differing in centromere position of the seventh largest pair of chromosomes), and hybridization between these different forms occurs in ecotones. The Grand Canyon material is being investigated in the perspective of the broader problem of the variation and evolution of these lizards, with implications bearing on past distributions of vegetation communities.

# # #

INVESTIGATION OF THE HERMIT AND SUPAI FORMATIONS OF GRAND CANYON

INVESTIGATOR: Edwin D. McKee
U. S. Geological Survey, Denver, Colorado

SUMMARY OF PROGRESS: The Supai Formation of Grand Canyon region is raised in rank to Supai Group and divided into four formations. Widespread surfaces of erosion and thin conglomerate beds separate these formations which range in age from Early Pennsylvanian to Early Permian. From oldest to youngest they are named the Watahomigi, Manakacha, and Wescogame formations and the Esplanade Sandstone. The type sections of these formations are in Havasu Canyon in the vicinity of Supai village.

A preliminary publication covering the data described above is in press and scheduled to appear as a chapter in a U. S. Geological Survey Bulletin during the winter of 1975. The monograph of the Supai-Hermit is scheduled to be published as a Professional Paper of the U. S. Geological Survey. It is now about one-third written and about the same amount is completed on the illustrations.

# # #

MORPHOLOGY AND SUBSPECIES ENDEMISM AS AN EXPRESSION OF ECOLOGICAL ISOLATION

INVESTIGATOR: Ronald S. Wielgus

SUMMARY OF PROGRESS: Research was suspended during the summers of 1972 and 1973 but reactivated in the summer of 1974. Collecting of insects was maintained during a four day period in late June 1974 on Bright Angel Point and at Neal Spring and Point Imperial. Despite a severe drought preceding the collecting, several interesting species of Geometridae (Lepidoptera) and sawflies (Hymenoptera) were taken. These were sent to specialists for study and are to be returned to Arizona State University for permanent holding. Among the Geometridae are two species presumed to be undescribed. The primary objective of taking a series of *Speyeria* near *coronis* was unsuccessful due to the drought conditions and as a result the breeding grounds could not be located.

It is recommended that investigations be continued on the *Speyeria* and Geometridae. A special effort should be directed toward the sawflies as these are poorly known and considered rare in Arizona. Two species of sawfly taken at Neal Spring, now the subject of study, are represented by only one specimen each and both are presumed to be undescribed. Research should be expanded to include this primitive Hymenoptera family with additional field work in the life histories. The original time frame of 5 years may have to be adjusted accordingly

# # #

CORRELATION OF MODERN FLORA WITH THAT OF ANCIENT PACKRAT NESTS

INVESTIGATOR: James I. Mead
University of Arizona, Tucson

SUMMARY OF PROGRESS: In essence, my work is finished, however, I believe that I may have to make a few more trips down to Shinumo Creek area. So far I have written a paper co-authored with T. Van Devender which is now in press.

# # #

PETROGRAPHIC AND MICROPALEONTOLOGICAL ANALYSIS

INVESTIGATOR: Arthur Chadwick

SUMMARY OF PROGRESS: A slide breccia in the basal Tapeats Formation in the Grand Canyon, Arizona, was first reported by Sharp in 1940. Subsequent investigations have revealed a second similar deposit located southwest of that described earlier. The two are disjunct across Ninetyone Mile Canyon and apparently represent at least two source areas. The newly described breccia consists of two separate masses lying along the east and west facing flanks of an upper precambrian monadnock at the base of Cheops Pyramid. It is similar in extent and composition to the original slide and appears to be contemporaneous, suggesting that the slides may have been triggered by a singular regional element such as tectonic shock.

A detailed analysis of the original slide has revealed several features of interest. The slide is composed of a more or less continuous layer of breccia interrupted at intervals lenticular masses which appear in cross-section to radiate from the source area. The layer can be followed without interruption to the parent outcrop at the head of the west fork of Ninetyone Mile Creek. Thus a unique opportunity is afforded for reconstructing the paleohistory of the slides.

Several trips have been made into the area by foot with good success. However, the journey requires about 1-1.5 days each way and it is necessary to pack water. The project would be greatly facilitated by use of the NPS helicopter. Funds are now available for this, and it is hoped that a trip may be arranged for February or April of this year.

# # #

PALEOMAGNETISM IN FOLIATED METAMORPHIC ROCKS

INVESTIGATOR: S. E. Cebull

SUMMARY OF PROGRESS: So far, we have not been able to successfully utilize the four samples collected owing to their weak magnetic character. Thus, no change in the state of progress as reported previously.

# # #

A LIMNOLOGICAL STUDY OF THE COLORADO RIVER WITHIN THE GRAND CANYON

GRCA-N-15

INVESTIGATOR: R. Roy Johnson

SUMMARY OF PROGRESS: The study includes investigations on the biological, physical and chemical parameters of the river. Baseline information is being gathered in order to establish an environmental monitoring program to aid in future management of the river. Special emphasis is being placed on the effects of environmental changes since the construction of Glen Canyon Dam. The current status of threatened wildlife and introduced species is being established.

# # #

CHANGES IN FLUVIAL DEPOSITS OF THE COLORADO RIVER OF THE GRAND CANYON

INVESTIGATORS: Robert Dolan, University of Virginia
Alan Howard, Department of Environmental Science

SUMMARY OF PROGRESS: The study entails investigation of the processes which are eroding the beaches along the Colorado River. These beaches are of importance to river recreationists as camp sites and support a riparian ecosystem entirely dependent on the beaches for its existence.

A major article appeared in the July-August 1974 issue of the *American Scientist*, Vol. 62(4), p. 392-401 by Dolan, Howard and Arthur Gallenson. The summary includes the following: "In 1963, the river was impounded by Glen Canyon Dam, and the water released by the dam is a turbid-free, powerful erosive agent. . . . The sediment-free water erodes the existing beach areas but does not resupply the sand lost either to the wind or directly into the river. The reduced discharge is less capable of clearing the river channel of flash-flood material brought in by tributaries, thus creating hazardous rapids and falls that may eventually become unnavigable."

# # #

THE NATURAL HISTORY OF FISHES, MAMMALS, AMPHIBIANS, AND REPTILES OF THE INNER GORGE, GRAND CANYON

INVESTIGATORS: Royal D. Suttkus, Tulane University, New Orleans
Clyde Jones, U. S. National Museum
Glenn H. Clemmer, Mississippi State University

SUMMARY OF PROGRESS: The study is concerned with the changes along the Colorado River since the construction of Glen Canyon Dam. Fishes, mammals, amphibians, and reptiles are being studied with emphasis on habitat selection, seasonal fluctuation in activity, and other natural history. Photographs include documentation of habitat for vertebrates and color variation in given species of reptiles as one progresses down-river. The fish fauna of permanent side streams is being completed. Documentation of vegetation damage, e.g., Ocotillo and legume shrubs (e.g., cat-claw acacia) being almost completely destroyed, is continuing in areas where burros exist. Special consideration is being given the effects of this burro damage on wildlife habitat.

# # #

COLORADO RIVER CARRYING CAPACITY STUDY

INVESTIGATORS: F. Yates Borden)
Harmer A. Weeden) Pennsylvania State University
Don N. Thompson)

SUMMARY OF PROGRESS: The primary objective of the project was to locate beaches and estimate their carrying capacities as campsites for river-running parties on the Colorado River from Lees Ferry to Grand Wash Cliffs at the head of Lake Mead. To meet this objective beaches now used as campsites or having a potential as sites were selected for study on the basis of aerial photography and prior knowledge. Selected beaches were visited to collect information regarding sleeping capacity, activity areas, sanitation disposal sites, campfire sites, bathing and swimming areas, raft mooring sites and other data such as vegetational encroachment, beach erosion and flood danger. Additional studies included sound-level evaluations of motor noise from pontoon rafts on the river and mapping of selected beaches.

# # #

BIRDS OF THE GRAND CANYON REGION

INVESTIGATORS: R. Roy Johnson
Steven W. Carothers, Museum of Northern Arizona, Flagstaff

SUMMARY OF PROGRESS: The aim of this project is to produce a popularized, scientifically accurate book on the avifauna of Grand Canyon National Park and vicinity. It will entail past park records, distribution, migration, breeding biology, and habitat information regarding the avifauna of this region. Current plans are to pattern the publication after Ro Wauer's "Birds of Big Bend National Park and Vicinity."

# # #

BLUE SPRINGS AS A BARRIER TO *RHINICHTHYS OSCULUS*

INVESTIGATOR: Stewart W. Aitchison
Museum of Northern Arizona, Flagstaff

SUMMARY OF PROGRESS: No field work was carried out during 1974 due to lack of funding. This project could be completed in a 1-year period if funds became available.

# # #

AN ECOLOGICAL SURVEY OF THE COLORADO RIVER AND ITS TRIBUTARIES, BETWEEN LEES FERRY AND THE GRAND WASH CLIFFS, GRAND CANYON, ARIZONA

GRCA-N-16

INVESTIGATORS: Steven W. Carothers, Museum of Northern Arizona
R. Roy Johnson

SUMMARY OF PROGRESS: The ecological survey has been underway since October 1973. The first phase of the project has been completed with a report submitted on 31 December 1974 to the National Park Service, Grand Canyon, Arizona. Areas of investigation covered in phase I were as follows: (1) analysis of human impact on the biota of the riparian zone of the Grand Canyon, (2) classification of the major vegetational communities of the Grand Canyon study area, (3) man's impact, especially as it relates to Glen Canyon Dam, upon the flora of the riparian zone of the Colorado River as determined by photographic comparisons, (4) a catalog of vascular plant and vertebrate species of the riparian zone of the Grand Canyon, (5) suggested alternatives for the management of the riparian zone of the Grand Canyon, and (6) recommendations for additional research needs and monitoring.

Phase II of the ecological survey is now underway, and in addition to refining and continuing the above investigative goals, new areas of research include: (1) the preparation of a vegetation map (1 inch = 1 mile) from river level to the 500 ft contour level above the river, (2) an analysis of population densities, home ranges, and demography of important vertebrates, (3) the impact of feral asses (*Equus asinus*) on the native environmental constituents, and (5) a preliminary inventory of insect life within the river gorge of the Grand Canyon.

During phase I, 1112 man-work-days were expended on the ecological project. This included seven float trips through the 280 mile study area, three extensive backpack trips into remote tributaries, two helicopter trips to isolated sections of the canyon, and many hours of library and laboratory work.

SIGNIFICANT FINDINGS: During phase I, many heretofore unreported plants and animals were found to be inhabiting the environs of the riparian habitat of the Colorado River with the Grand Canyon. Of 596 vascular plant species included in our catalog of plants, 41 are new records to the previously compiled lists of Grand Canyon flora. The vertebrate checklists are replete with many other significant records, e.g., the collection of the Ovenbird (*Seiurus aurocapillus*), representing a new species for not only the Grand Canyon region, but Arizona as well. Perhaps the most significant result of our investigation was the quantification of the habitat damage caused by populations of feral asses (*Equus asinus*) in the lower canyon regions.

# # #

PETROLOGY OF THE TAPEATS SANDSTONE

INVESTIGATOR: Barrett L. Burgert
Northern Arizona University, Flagstaff

SUMMARY OF PROGRESS: Research has been completed, submitted and accepted as a Masters Thesis by Northern Arizona University. It is on file and available for loan from the Main Library, N.A.U.

# # #

INVESTIGATIONS ON AQUATIC *HEMIPTERA*

INVESTIGATOR: John T. Polhemus

SUMMARY OF PROGRESS: A manuscript is 90% complete describing the aquatic *Hemiptera* fauna of the canyon and surroundings.

A new speices of Ochteridae is described from the Canyon Gorge, and the western mountains of Mexico.

# # #

AGE AND CONODONT BIOSTRATIGRAPHY OF THE SUPRA-MUAV AND TEMPLE BUTTE FORMATIONS, GRAND CANYON, ARIZONA

INVESTIGATOR: Dietmar Schumacher
University of Arizona, Tucson

SUMMARY OF PROGRESS: Up to several hundred feet of questionable Cambrian through Devonian strata crop out over a wide area of northern and northwestern Arizona. Due to the lack of macrofossils in these strata, considerable uncertainty exists regarding the placement of these strata within the Cambro-Devonian interval. In order to more precisely determine the age and distribution of these strata in the Grand Canyon, the Temple Butte and supra-Muav formations were systematically sampled for conodonts at several locations within the Grand Canyon. A small conodont fauna has been recovered from Temple Butte and supra-Muav (?) carbonates in Matkatamiba Canyon (river mile 148). These conodonts, the first diagnostic fossils found in these strata in this part of the canyon, suggest an early Late Devonian age for these strata. During 1975, the Temple Butte and supra-Muav will be sampled for conodonts at four other localities within the Grand Canyon. The presence of conodonts in these formations makes possible more precise correlations with Devonian rocks in southern Arizona and adjacent states.

# # #

FIRE ECOLOGY OF NORTH RIM FOREST ECOSYSTEMS

INVESTIGATOR: Peter S. Bennett

SUMMARY OF PROGRESS: The broadly conceived and high priority portions of this project are nearing completion. We have reported, in previous years, the derivation of a simplified prescription formula, the gathering of fuel and successional data. These data have been combined with recently gathered information and are now being incorporated into a ponderosa forest ecosystem model.

Project progress in calendar year 1974 lies principally in: (1) the development of methodology for the determination of past fire history from tree ring chronologies, testing of the method, and of course, determination of the fire history of the experimental site; (2) increasing the data base on plant productivity; (3) increasing the data base on the lethal effects of fire on tree species; and, (4) determination of the effect of fire on soil microflora in general and fuel decomposition in particular. Overall project progress was hampered by unusual weather conditions that prevented the setting of two research fires, and my protracted period of recovery from an injury. These have caused project completion and publication of results to be put off for a year.

The frequency of naturally occurring fire was judged to be of considerable importance for determining the role of fire in natural ecosystems. The fire incidence records are of little use, since they have been gathered during the past 6 years which has been a period of active fire suppression. The investigator, therefore, must seek fire data from a period before fire suppression was actively practiced. This has usually been done by examination of trees for fire scars, a method that gives data biased toward large intense fires and topographically biased toward trees growing on sloping sites. We have developed a method that measures perturbations in tree growth patterns, as measured by the lack of correlation between ring width measured on tree cores from experimental trees and on regional tree ring chronologies.

Except in the case of the very lightest burns, ponderosa pine show ring perturbations. These breaks in the normal ring sequence occur when fire intensity is much too low to cause fire scars. By extensively sampling a stand, we can trace its past fire history from the present back to the beginning of the master chronology in about 1620. These data have been derived for the experimental areas of Point Sublime. In the summer of 1975 the data base will be expanded to include the entire ponderosa pine forest on the North Rim.

Numerous measurements of standing biomass have been made. Measurements of species biomass have been combined to form successionally important groups, i.e., broadleaf trees, coniferous trees, shrubs, perennial herbs, and annual herbs. Clip transects or estimation procedures were employed as appropriate. These data are now complete; no further work will be undertaken in the near future.

The lethal effects of fire on standing vegetation burned under conditions of varying energy release rates was investigated. These data are not wholly satisfactory from the statistical point of view, since the data base is limited to four documented research fires. The problem of reliability is particularly severe for very intense fires. However, I judge that the resource manager will have little interest in intense fire, and that this problem will therefore not cause undue difficulty. The data reliability for a narrow range of medium fire intensities is satisfactory. More data will be gathered in the summer of 1975, with fully documented large burn sites and thereafter on a catch-as-catch-can basis, with smaller sites dedicated to this type of data gathering. Results of previous work can then be modified and updated as necessary.

Work is now underway on the effects of fire on fuel composition rate. We are examining the effects of soil temperature alteration on the metabolic rate of the microflora caused by removal of insulating layers of duff and litter, as well as the effect of ash amendment. This work is being undertaken by Katherine Shoemaker. We are employing standard monometric techniques in the South Rim laboratory for this work. This phase of the project will continue into the latter half of fiscal year 1976.

All of the above data are being incorporated into a model that has been up and running for several months now. This model forms the principal means for guiding the future course of the project, as well as the method of integrating project data. Because it is so important for our work, I will list the model's principal inputs and outputs.

Inputs

1. Vegetation Regeneration - whose components are: broadleafed trees, coniferous trees, shrubs, perennial herbs, annual herbs.

2. Vegetation Growth - components are the same as for regeneration.

3. Initial Vegetation Stocking - components are the same as for regeneration and growth.

4. Mortality - components are the same as for regeneration, growth, and initial stocking.

5. Initial Fuel Loadings - whose components are: fine, point 0.1-1 inch, 1-3 inch, 3-6 inch, heavy.

6. Fire Frequency.
7. Ignition Timing and Fuel Moisture - input by Monte-Carlo methods.

Outputs

1. Standing Biomass - compartmented as before.
2. Fuel Loadings - compartmented as before.
3. Size Distribution - (DBH) for trees.

After every simulated fire (in addition to the above outputs):

1. Fire Energy Release Rate.
2. Lethal Effect on Trees.
3. New Biomass of Trees (DBH) - compartmented as above.
4. Addition of Fire-Killed Fuels.
5. New Fuel Distributions - compartmented as above.

Progress on the contract let to the Museum of Northern Arizona is progressing satisfactorily. They are examining the effects of fire on small mammal and bird populations.

The results of small portions of the major study were published in the spring issue of *Plateau* and were presented in the fall at the Grand Canyon Research Symposium.

# # #

PHYSIOLOGICAL ECOLOGY OF SELECTED ARID SITE PLANT SPECIES

INVESTIGATOR: Melinda Hurst

SUMMARY OF PROGRESS: Collection area. South rim of the Grand Canyon, in the ponderosa pine community understory, and on rock out-croppings.

Plants collected. 42 species of desert ephemerals.

Reason. For a comparative study between the pinyon-juniper and the ponderosa pine understory, measuring the internodal lengths, and other physiological manifestations of moisture stress. The above is in fulfillment of the data needed for my masters degree in arid ecology.

No whole plants were destroyed in my analysis, however some influorescenses were desiccated in taxonomic classification. The specimens were pressed and turned over to the herbarium of the Brigham Young University. There they were mounted. Thank you for the opportunity to complete my research.

# # #

GRAND CANYON MARINERS

INVESTIGATOR: O. Dock Marston

SUMMARY OF PROGRESS: All major data are assembled leaving the usual minor items for filling.

# # #

CONODONT BIOSTRATIGRAPHY OF THE MISSISSIPPIAN ROCKS OF NORTHWESTERN ARIZONA

INVESTIGATOR: David R. Walter
Arizona State University, Tempe

SUMMARY OF PROGRESS: I am anxious, after 18 months of studying recent carbonates at Eniwetok Atoll, Marshall Islands, to begin work on the project again.

# # #

COLORADO RIVER RESEARCH PROJECT

INVESTIGATOR: R. Roy Johnson

SUMMARY OF PROGRESS: This research project has been designed to answer questions regarding the ecological interrelationships between members of the wild fauna and flora as well as the ecological and sociological implications of human visitors. We are concerned with the ecological interactions among plants and animals, the effects of humans on one another, the impact of man on the natural environment and the role of plants and animals in the park visitor's experience.

The research on the Colorado River between Lees Ferry and Lake Mead can be divided into ecological studies on one hand, and socioeconomic studies on the other hand. Ecological investigations are further divided into riparian studies and aquatic studies. An additional type of investigation, beach erosion study, is concerned with the interface between riparian and aquatic habitats. In addition, a study of human waste disposal within the riparian zone is under consideration.

Socioeconomic studies have been divided into an ongoing study of the sociology of river recreation and a proposed study of the economics of the operation of river-running concessions and river recreation. Ramifications of ongoing studies often become evident as the research progresses. An outstanding example, documented by the Museum of Northern Arizona, regards the degradation of beaches by burros and consequential severe impact on populations and species diversity of plants and associated animals.

The greatest amount of progress during 1974 was made on the riparian studies. In December 1974, a report was received from principal investigator, Steven W. Carothers, and members of his staff at the Harold S. Colton Research Center, Museum of Northern Arizona, Flagstaff. The 171 page report, entitled "An Ecological Survey of the Colorado River and its Tributaries between Lees Ferry and Grand Wash Cliffs," discusses human impact on the biota, lists all known species of vertebrates and vascular plants and discusses vegetational communities of the Grand Canyon Riparian Zone. In addition, 17 sites are discussed, with accompanying pre-Glen Canyon Dam photographs compared to recent matching photos, in regard to post-dam vegetational encroachment in the riparian zone. The following manuscripts are being sent to various journals for publication:

1. "Population Dynamics of Small Mammals in the Grand Canyon," by D. S. Tomko, S. W. Carothers, and G. A. Ruffner.
2. "History of Biological Research in the Grand Canyon Region," by D. B. Wertheimer and J. H. Overturf.
3. "Recent Observations of the Status and Distribution of Some Birds of the Grand Canyon Region," by S. W. Carothers and R. R. Johnson.
4. "Recent Notes on the Distribution of Some Mammals of the Grand Canyon Region, Arizona," by G. A. Ruffner and S. W. Carothers.
5. "The Reptiles and Amphibians of the Grand Canyon," by D. S. Tomko.
6. "The Occurrence of Ovenbirds in Arizona," by R. R. Johnson, E. L. Smith, D. S. Tomko, and L. Haight.

See also:

A limnological study of the Colorado River within Grand Canyon - R. Roy Johnson GRCA-N-15 (Investigator's Annual Report, 1974).

An ecological study of the riparian zone of Grand Canyon's Inner Gorge - Steven W. Carothers and R. Roy Johnson GRCA-N-16.

Robert Dolan, Alan Howard, and Arthur Gallenson, Man's Impact on the Colorado River in Grand Canyon. *Am. Sci.* 64(4):392-401.

J. Eugene Haas, Joyce Nielsen, and Byron Shelby, "River Contact Study." (Investigator's Annual Report, 1974)

# # #

GRAND TETON NATIONAL PARK

A PILOT STUDY OF MODELING THE SNAKE RIVER FLOAT TRIP, GRAND TETON NATIONAL PARK

INVESTIGATORS: Alan Jubenville) University of Wyoming
G. Robert Peel, Jr.)

OBJECTIVES: The specific objectives of the study were to: (1) identify the desirable landscape element of the Snake River corridor; (2) develop time-distance floating model; (3) identify components of the service and their possible effects on the floating experience; (4) identify social factors and activity participation.

METHODS: The methodologies employed were: (1) unstructured interviewing to identify the social and service components of the paradigm; (2) field observation to identify desirable elements of landscape and to determine the degree of socialization among participants; (3) direct measurement to plot the visual corridors and develop the time-distance relationships of the floating trips.

DISCUSSION: The perception of the guided floater is molded by advertising. People's anticipations are developed through advertising since most of them are totally unaware of the trip prior to arriving in the Jackson area and have no experience in river floating. Thus, realistically much of the demand is created, rather than servicing an existing demand. Wildlife viewing, scenic viewing, and undeveloped landscape (not a pristine environment) rank as the highest recreational needs.

In terms of motivation, the participant is from the urban environs and seeks out such trips because he feels a need to constructively occupy his time--he needs something to do. Furthermore, the guided trips are chosen because they are program-oriented in terms of time to be spent, costs involved, landscape elements to be enjoyed, and elimination of uncertainties and insecurity in a self-conducted trip. The typical visitor can then maintain a scheduled travelogue and enjoy more of the parkscape, but with minimum effort and inconvenience and maximum personal security. In sum, the urban visitor appears to want to enjoy more of the parkscape but is reluctant unless he can minimize the uncertainties of time (scheduling) and the potentially hostile environment in which the travel would take place (away from the developed roads).

Interestingly, few visitors are sufficiently personally motivated to return for a second visit.

PLANNING MODEL: 1. Resource aspects. The landscape elements and the water resource are important to the guided visitor in that they provide the aesthetic and transportation media for the floating. However, neither are manipulable in terms of altering the resource to change the visual corridor, the length of time for the float trip, etc. Consequently, these elements would be viewed as "uncontrolled" variables.

2. Social aspects. Socialization and territorialism are important to the guided visitor. He is willing to share the watercraft while maintaining his family (or personal group) territory. Thus, the social aspects (in terms of management of the visitor) appear to be manipulable without infringing on the personal space or territory of the family. In other words, within some limits, one can alter party size without lowering the quality of the social experience.

3. Service components. There are inherent limitations at access points that naturally separate the craft as they are launched. The queuing problems on the water are created by craft floating at differential speeds and private floaters who can launch at any place--plus, the compulsive desire to exit at Moose regardless of entrance point.

A mass transit system in the park (which would also handle deflated crafts) could eliminate some of the problem by handling the service load on a scheduled basis.

4. Resource limitation. Because of existing policy which limits egress from floats, environmental degradation appears to be minimal, except for possible intrusion on the normal behavior of wildlife. Some hardening of the launch sites may be necessary to minimize further degradation and erosion--without modernizing the launch site itself.

Again, the potential problem exists with the private floater because he is allowed to stop any place along the route--without control on behavior or waste disposal.

FUTURE RESEARCH: There are three research efforts that must be developed:

1. Baseline data on perception and motivation. If these type of data had been developed 10 years ago, the Park Service would have a basis for decision-making on carrying capacity. People may have enjoyed themselves 10 years ago but since then have sought other floating experiences because of crowding, etc. on the Snake River. The manager must recognize that carrying capacity is a dynamic situation in which recreation use comes into equilibrium with existing conditions. In other words at any level of use, there will be visitor satisfaction (even with crowding, resource deterioration, etc.). The manager must decide what type of experience should be provided; this establishes the upper limit of carrying capacity (number of people per unit area or unit of time).

2. Calibration of registration stations. Since the baseline data in No. 1 will be developed using a mail questionnaire and the sample will come from registrations, it is imperative

that the registration system be improved and properly calibrated. Benefits to proper management will be shown also.

3. Standardized interpretive program. This will be the emphasis of the third year of research since much of the visitor perception is molded by the boat operator and the type of program presented.

# # #

CLIMATOLOGICAL STUDIES OF YELLOWSTONE AND GRAND TETON NATIONAL PARKS

INVESTIGATOR: Richard A. Dirks
University of Wyoming

OBJECTIVE: To describe the climate of Yellowstone and Grand Teton National Parks based on all available climatic records.

SUMMARY OF PROGRESS: A history of climatic observations is described. Due to the complexity of the region's topography and the frequent location of climate stations in locales of moderate climatic conditions, a complete description of the park's diverse climate is not possible. In particular, the mountainous terrain is not adequately represented by existing data.

Temperatures range from 40°F to 70-80°F in the summer. The lowest recorded summer temperature is 9°F at Canyon on 25 August 1910. Winters are cold with daily maxima often below freezing. The record low is -66°F at Riverside RS (West Yellowstone) on 9 February 1933. The generally cold winters are of local origin.

Normal annual precipitation at standard climatic stations ranges from about 11 inches at Gardiner to 38 inches at Bechler River. The highest annual precipitation occurs over the southern Yellowstone Plateau. The areas of high mean annual precipitation show major increases in precipitation during mid-winter months. The remainder of the park's region has a fairly uniform distribution of precipitation with small peaks during June and mid-winter.

Snowfall ranges from near 50 inches at Gardiner to 400 inches in the southwestern portion of Yellowstone National Park. At higher elevations snowfall may locally reach 600 inches.

Contemporary wind records are sparse. Jackson Hole is described as having the lightest wind. Winds at Moose are reported to average 8 mph in a mean southwesterly direction. Strong winds from thunderstorms (60-80 mph) have occasionally been reported at the fire lookout on Mount Washburn and Mount Holmes.

Sunshine records are available only at Yellowstone Park Headquarters (terminating in June 1941) which averages 70-75% sunshine during July and August, 65% during June and September, and about 40% during mid-winter when frequent storms move through the area.

The region is broken down into 7 areas. Detailed climatic data are presented.

# # #

GREAT SMOKY MOUNTAINS NATIONAL PARK

COMPETITIVE INTERACTIONS AMONG THE TERRESTRIAL SALAMANDERS *PLETHODON JORDANI* AND *PLETHODON GLUTINOSUS*

INVESTIGATOR: Nelson G. Hairston
University of Michigan

SUMMARY OF PROGRESS: The manipulations of salamanders were carried out in the manner described in research plans that had been submitted. The only deviation concerned moving local *Plethodon jordani* within the vicinity of Hughes Ridge, involving Plots 3, 10, 11, and 12. Experiments conducted near Highlands, N. C. in 1973-74 showed that local transfers are successful. Hence the 4 plots were not required.

In a series of about 30 nights, starting 23 April and ending 8 October, the following removals were carried out.

Plethodon jordani	No. removed
From Plot No. 1	72
" " " 6	31
" " " 7	71
" " " 8	37
" " " 9	67
" " " 14	119
From near Plots 10 & 12	37
TOTAL	434

All except 4 were introduced onto the reciprocal plots at Courthouse Creek, Pisgah National Forest. The remaining 4 were depostied in the Museum of Zoology, University of Michigan.

In addition, 139 *Plethodon glutinosus* were removed from Plots 2, 4, 7 and 9. They were released 2 miles away beside Bradley Fork. As planned, 471 specimens of gray-cheeked *P. jordani* from the Courthouse Creek plots were introduced onto Plots 1, 7, 8 and 9 on Hughes Ridge. All plot numbers are as indicated in previously submitted reports.

The results to date are encouraging in that I have found introduced salamanders in very satisfactory numbers as long as 7 weeks after the last introduction onto the plots. Thus, the indications are that the experiment will eventually yield definitive results.

# # #

THE IMPACT OF THE EUROPEAN WILD BOAR ON HIGH ELEVATION PLANT COMMUNITIES

INVESTIGATORS: Susan Power Bratton) Cornell University
Hal Tatelmann)

SUMMARY OF PROGRESS: The most heavily damaged areas on the State Line Ridge are hardwood forests in mesic locations. The most heavily damaged plot sampled was almost completely bare of herbaceous plants; cover was about 2% of the expected value. A number of stands adjoining the Appalachian Trail were extremely heavily disturbed; covers varied from about 5% to 80% of the expected cover. Very sedgy beech understory showed little or no damage from hog rooting. This indicates that the presence of certain rhizomatous herbs is more important in determining which stands are likely to be disturbed than is the presence of beech in the overstory.

A large number of plant species, including quite a few wild flowers, are being damaged by hogs. These include spring beauty, fawn lily, trilium (*T. erectum* and others), Turk's cap lily, Tennessee chickweed, fringed phacelia, lady fern, violets, toothwort, wood anemone, white wood aster, Curtis's goldenrod, Dutchmann's britches, and many others. Tree roots are frequently exposed or otherwise injured. After heavy rooting, the litter layer and organic horizon of the soil are so completely mixed with each other and with mineral soil from lower horizons that some animals such as centipedes and salamanders may not find a suitable habitat anywhere on the forest floor.

Spruce-fir forests are not as liable to hog damage as hardwoods. Hog movement and activity in these forests are increasing, however. Grass balds are rooted but they recover more quickly than do forest understories. They may suffer some change in species composition.

The final report will include recommendations for further research on hog food habits, movements, and hog control.

# # #

MERCURY AND OTHER TRACE ELEMENTS IN FISH AND BENTHIC INVERTEBRATES

INVESTIGATOR: John W. Huckabee
Oak Ridge National Laboratory

SUMMARY OF PROGRESS: 1. A manuscript "Mercury concentrations in fish from the Great Smoky Mountains National Park," by John W. Huckabee, Cyrus Feldman, and Yair Talmi, Oak Ridge National Laboratory, has been accepted for publication in *Analytica Chemica Acta.*

Benthic insects from Walker Prong, Beech Flats, and Noland Creeks have been collected and analyses are proceeding.

2. Mercury concentrations in GSMNP fish are probably as low as can be found in nature for species analyzed.

3. Since unpolluted areas in the eastern United States are very rare, the GSMNP provides a valuable source for base level studies of trace elements in the environment.

# # #

EFFECTS ON AQUATIC BIOTA OF LEACHING OF SULFIDE-RICH ROCKS

INVESTIGATOR: John W. Huckabee
Oak Ridge National Laboratory

SUMMARY OF PROGRESS: 1. A manuscript "Unanticipated Impact on Aquatic Biota of Road Construction in Regions of Sulfide Mineralization," is in the late stages of preparation; it will be submitted to an aquatic ecology journal. A second manuscript on the effects of the road construction on salamanders is in early stages of preparation and will be submitted to a herptelogical journal. One and possibly two other manuscripts may be prepared based upon this data set.

2. The impact on aquatic biota (fish, salamanders, and benthic insects) of road construction in GSMNP can be detrimental when rocks of high sulfide content are disturbed. Fisheries can be destroyed and rare species endangered under worst conditions.

3. Further studies may be required, particularly with regard to the Fontana Reservoir North Shore Road or the Transmountain Highway. Communication between ORNL and GSMNP staff should be continued and encouraged.

# # #

PRELIMINARY SURVEY OF AQUATIC HYPHOMYCETE FLORA OF THE SOUTHEASTERN U. S.

INVESTIGATOR: Barbara Juanita Dyko

SUMMARY OF PROGRESS: I have been collecting in the Little Pigeon River and Abrams River in Cades Cove. I have found the following aquatic hyphomycetes on leaves: *Alatospora acuminata, Anguillospora longissima, Articulospora tetracladia, Clauariopsis aquatica, Clauatospora longibrachiata, Culicidospora aquatica, Lemonniera aquatica, L. cornuta, L. terrestris, Lunulospora curuula, Tetrachaetum elegans, Tetracladiun marchalianum, T. setigerum, Tricladium angulatum, T. gracile, Triscelophorus monosporus, Varicosporium eludeae,* and several unidentified species.

Preliminary work will be completed by March 1975. I will begin the main body of research at that time which will include two sites in the Smoky Mountains National Park.

# # #

THE FUNGI, ESPECIALLY THE AGARICS (MUSHROOMS), OF THE PARK

INVESTIGATOR: L. R. Hesler
University of Tennessee

SUMMARY OF PROGRESS: A study of the fungi, with special reference to the conspicuous forms, has been my special interest since the fall of 1919, when I came to Tennessee. In November of that year, I spent a day in the Miry-Ridge Area, and found fungi so abundant that I made the fungi of the Smokies my special research. Before the park was established, I collected there as time permitted. Since its establishment, I have been favored not only with a permit, but with the cooperation of park officials to an unusual extent. For this I am appreciative.

Although I had a permit to collect there in 1974, my collecting there this year has been limited. The reasons: (1) since 1971, I have been limited to Knoxville in my driving an automobile, because of health; (2) in 1974, I was able to visit the park on 4 or 5 different days by being taken by others who were on a collecting expedition there; (3) thus, in 1972, 1973 and 1974 I have remained close to my desk and have been writing and publishing on materia at hand, including collections taken from the park over the last 55 years. I now have two manuscripts of book-length, which contain among other areas, materials from the park.

# # #

EVOLUTIONARY STUDIES ON PLETHODONTID SALAMANDERS

INVESTIGATOR: Richard Highton
University of Maryland

SUMMARY OF PROGRESS: During 1974, we completed analysis of blood protein polymorphisms at 70 localities throughout the range of *P. jordani* (including 9 in GSMNP). At present the data are being analyzed and comparative gels being made.

During 1974 we began the next project on *P. jordani* and *P. glutinosus*, which is a comparative study of enzyme polymorphisms throughout the range of both species. This includes an analysis of the hybridization between the two species in the southern Appalachians, including those areas in the eastern part of the park where the two species hybridize rather extensively. Most of the collections made this summer were for the pilot phase of this project.

In collaboration with Preston Webster of Harvard University, studies on the biochemical taxonomy by comparative enzyme electrophoresis have shown that the GSMNP collections of *P. cinereus* do not belong to that species and a paper is in preparation which will show their relationships with other eastern small plethodons.

In collaboration with Steven Tilley of Smith College, we have been doing work on the *Desmognathus* that I collected in the park during the years 1961-68, which shows conclusively that there are more species of that genus of salamander in the park than previously recognized. Tilley is doing a lot of electrophoretic work on that genus in the southern Appalachians and we hope to have that study completed within the next year or two.

# # #

AMPHIBIANS AND REPTILES OF GREAT SMOKY MOUNTAINS NATIONAL PARK

INVESTIGATOR: James E. Huheey
University of Maryland

SUMMARY OF PROGRESS: Study was originally begun on two projects: (1) preparing a report on reptiles and amphibians of GSMNP; (2) studying salamanders of the genera *Plethodon* and *Desmognathus*.

Project #1 was completed in 1967 with the publication of *Amphibians and reptiles of Great Smoky Mountains National Park*, co-authored with Arthur Stupka. I am continuing to gather records for a possible revision and I had hoped to attempt to study the turtle fauna more closely last summer but other duties prevented me.

Project #2 is a continuing study of certain aspects of the life history, ecology, and evolution of *Plethodon* and *Desmognathus* salamanders, both in the park and in surrounding areas of the Southern Appalachians. In 1974, my work continued on rockface populations of salamanders in the park. I also did some collecting and observing on forest populations and I have submitted a manuscript for publication.

# # #

BIOSYSTEMATIC STUDY OF THE GENUS *VIBURNUM* SECTION LANTANA (CAPRIFOLIACEAE) OF EASTERN NORTH AMERICA

INVESTIGATOR: Thomas H. Jones
North Carolina State University

SUMMARY OF PROGRESS: Collections in the park were three specimens (2 dup. ea.) ½ mile north of Alum Cave Bluffs Trail. Other collections not in the park from N. C., S. C., Va., Ga., Fla., Miss., Ala., Tenn., N. J., and Kentucky. Field work only during 1974.

# # #

EVOLUTIONARY STUDY OF *CLAYTONIA*

INVESTIGATOR: Walter H. Lewis
Washington University, St. Louis

SUMMARY OF PROGRESS: Cytological and anatomical study of park species of *Claytonia*, *C. caroliniana*, and *C. virginica*. We hope these data will be ready for publication early in 1976.

# # #

BEETLE POLLINATION OF *CALYCANTHUS FLORIDUS*: POLLINATOR BEHAVIOR AS A FUNCTION OF THE VOLATILE FLOWER OILS

INVESTIGATOR: Jeffrey H. McCormack
University of Connecticut, Storrs

SUMMARY OF PROGRESS: The work summarized below relates only to those findings pertinent to the Great Smoky Mountains National Park. Results of the entire project will be the subject of a publication in 1975. A copy will be forwarded to the park as soon as it becomes available.

The principal objective of research undertaken in the park during 1974 was to identify the pollinators of *Calycanthus floridus* var. *fertilis*, and to conduct field observations on pollinator behavior and the floral mechanism. At least 12 species of Coleoptera are involved in pollination of *Calycanthus* with varying degrees of effectiveness. Species collected in Blount County and Cocke County, Tennessee, include: *Nitidulidae: Carpophilus brachypterus* (Say), *C. corticinus* Er., *C. lugubris* Murray, *C. marginellis* Mots., *C. sayi* Parsons, *Colopterus truncatus* (Randall); *Rhizophagidae: Europs pallipennis* LeConte; *Phalacridae: Olibrus* sp.; *Lathridiidae: Melanophthalma* sp.; *Scolytidae: Monarthrum fasciatum* (Say); *Staphylinidae:* several species. These collections were made on 128 flowers during 20-21 May 1974. Collections and observations made during 1973 and 1974 in private and public lands in Tennessee, Georgia, and Connecticut suggest that as many as 42 species of Coleoptera may be involved in pollination (with variable degrees of effectiveness).

The significance of these findings are discussed in the forthcoming publication.

At a later as yet undetermined date I would like to compare the difference in pollinators found in flowers of the two varieties of *Calycanthus* (var. *fertilis* and var. *floridus*).

The support and assistance of the park personnel has been very gratifying both personally and professionally.

# # #

THE POPULATION STRUCTURE AND ECOLOGICAL GENETICS OF THE WHITE-LIPPED LAND SNAIL, *TRIODOPSIS ALBOLABRIS*

INVESTIGATOR: Gary F. McCracken
Cornell University

SUMMARY OF PROGRESS: This project is generally a study of the population structure of a land snail which is endemic to much of eastern North America. I have been looking at the demography of local populations using mark and recapture techniques and I have been interpreting this data in the light of information I have gained on the amount of genetic variability within these populations. This allows the interpretation of the population stragegy of this animal in terms of its demography and genetic attributes.

The work I did in the Smokies was part of a survey of the genetic variation on this species throughout its range. I am basically looking for patterns of genetic change over geographical areas or environmental gradients which will give insight into how this variability is maintained. I have not yet been able to identify any such patterns, partly because the populations I have collected are generally too far apart.

I have found several interesting things from the Smokies work. First, the Smokies are in an area where it was believed that two subspecies of this animal came into contact. I have found areas near the park and one area inside the park (Big Locust) where these two 'subspecies' are existing sympatrically but not interbreeding. My genetic analysis has shown that these animals are not interbreeding and are in reality distinct species. The subspecies were called *Triodopsis albolabris albolabris* and *T. a major*. Also, I have found very striking differences in the genetic composition of populations which are very close, only a few hundred meters from one another. I do not as yet know the causative basis of these differences, whether it is selection or founder effects which date from the establishment of these populations.

I would like to make additional collections in the Smokies this spring (1975) but I do not intend to do any detailed field work there for inclusion in my thesis which I am presently attempting to finish. After I secure a position, I very much want to do some detailed work in the Smokies and I would be very grateful if this were possible.

I anticipate that at least two publications will come out in the next year or so which include my work in the Smokies, I will send reprints of these when they are available.

# # #

COLLECT TWIGS AND BUDS (WINTER), LEAVES (SUMMER)

INVESTIGATOR: Frank H. Miller

SUMMARY OF PROGRESS: All field work has been completed and every effort is now being made to complete the office work by 1 April 1975.

A BIOSYSTEMATIC STUDY OF THE *FRAGILIS* COMPLEX OF THE FERN GENUS *CYSTOPTERIS*

INVESTIGATOR: Ronald W. Pearman
University of Tennessee, Knoxville

SUMMARY OF PROGRESS: *Cystopteris protrusa* was collected from the park in order to obtain cytological material. Material obtained was insufficient for proper determinations. Other localities must also be checked for possible different cytotypes within the park. No publications to date concerning the park material.

# # #

VASCULAR FLORA OF THE CAROLINAS

INVESTIGATOR: J. Dan Pittillo
Western Carolina University

SUMMARY OF PROGRESS: Collecting activity has increased with this year's agreement which resulted in the NPS Cooperative Park Studies Unit at Western Carolina University. Seventy-three specimens were collected this year, 14 of them county records according to the *Manual of the flora of the Carolinas*.

# # #

A MONOGRAPH OF THE GENUS *HYDNUM* FOR NORTH AMERICA

INVESTIGATOR: Joe H. Restivo
University of Tennessee

SUMMARY OF PROGRESS: My research has reached the stage where I am writing species descriptions and keys to species that I accept. Upon completion I will forward a complete set to the park headquarters at Sugarlands. I believe that I will have at least one new species from the park, but I will not be certain until I hear from K. Harrison in Nova Scotia.

# # #

MICROPALEONTOLOGIC STUDIES OF CHERTS FROM THE JONESBORO LIMESTONE, CADES COVE

INVESTIGATOR: J. William Schopf
University of California, Los Angeles

SUMMARY OF PROGRESS: Studies of thin sections revealed the occurrence of: (1) filamentous, branching fungi (apparently Phycomycetes); (2) filamentous, unbranched, sheath-enclosed blue-green algae (mostly oscillatoriaceans); (3) unicellular blue-green algae (chroococcaceans); and (4) a variety of acritarchs. The probable

Phycomycetes are, apparently, the oldest bonafide fungi now known in the fossil record (Ordovician); further work, however, is needed to confirm their identification. The assemblage of blue-green algae is of particular interest as an analogue of the Precambrian algal assemblages discovered in recent years.

# # #

INVESTIGATIONS OF THE GENUS *DESMOGNATHUS* IN THE SOUTHERN APPALACHIAN MOUNTAINS

INVESTIGATOR: Stephen G. Tilley
Smith College, Northampton, Massachusetts

SUMMARY OF PROGRESS: During the summer of 1974 the investigator, a co-worker (Robert B. Merritt, Smith College), and a student visited the southern Appalachians in June and spent several days working in the Great Smokies. Our efforts were directed chiefly towards collecting series of salamanders of the *Desmognathus ochrophaeus* complex, two species of which occur sympatrically in the Great Smokies. From our own collecting and from examining the large series of salamanders collected by Richard Highton during the past several years, we have determined that one of these forms is distributed across the entire park and occurs over a wide range of elevations, while the other seems to occur mainly at higher elevations from Starkey Gap (between Silers Bald and Thunderhead Mountain) to the Mt. Sterling area. The former species is smaller than the latter, usually has wavy dorsolateral stripes, is usually darker, and often bears red or yellow cheek patches. The latter, more high-elevation form is larger, has straight or slightly undulating dorsolateral stripes enclosing a light or bright yellow or red dorsal band, and never exhibits colored cheek patches. We have confirmed the distinctiveness of these two forms using gel electrophoresis of enzymes and other proteins. This technique enables us to directly observe genetic variation for protein structure and confirm that these very similar species are able to coexist without hybridizing. We are presently analyzing samples of specimens from the Great Smokies and several other southern Appalachian mountain ranges to determine the relationships between the two Great Smoky forms and populations of the *D. ochrophaeus* complex outside the park. It thus far appears as if a given locality outside the Great Smokies has but a single species of the *D. ochrophaeus* complex, and that the Great Smoky Mountains are quite unique in having two.

Several collections of *Desmognathus fuscus* (or of animals provisionally referred to this form) were also made, to confirm the presence of this species or species complex in various parts of the park and to provide samples for eventual electrophoretic analyses.

All specimens from which tissues (blood, viscera, and abdominal musculature) have been removed for electrophoretic analyses have been preserved, and all such specimens will eventually be placed in the collections of the National Museum of Natural History, Smithsonian Institution. An inventory of collections made during the past summer in the Great Smoky Mountains has been submitted to the park superintendent. The actual numbers of specimens taken are approximations, since counts were not made immediately after the specimens were taken and subsequent mortality in the laboratory has reduced the numbers for some series.

# # #

A STUDY OF THE BRYOPHYTES OF THE GREAT SMOKY MOUNTAINS NATIONAL PARK

INVESTIGATOR: Linda L. Spessard
University of Tennessee, Knoxville

SUMMARY OF PROGRESS: A total of 15 liverwort and 64 moss species were collected from the Greenbrier area, Ramsey Cascade trail, Alum Cove trail, and Clingman's Dome. A species list has been submitted to the park superintendent.

# # #

A MACROLICHEN FLORA OF THE HIGH-MOUNTAIN AREAS ABOVE 5000 FEET IN THE SOUTHERN APPALACHIANS

INVESTIGATOR: Jonathan P. Dey
Duke University

SUMMARY OF PROGRESS: I am presently preparing the macrolichen flora of the Southern Appalachian high-mountain areas as my dissertation to be presented this coming spring for my Ph.D. The flora, comprised of approximately 175-180 species, will include identification keys, descriptions, natural-product chemistries, and discussions (where relevant) of all species. In addition to several interesting, significant range extensions, two new species have been described and one new nomenclatural combination has been formed. One interesting aspect of my research was the identification of several lichen species known in North America only in the high-mountain areas of the Southern Appalachians which are approaching possible extinction in the Southern Appalachians and in some cases in North America as the spruce-fir forest continues to shrink due to lumbering, fires, and more recently the devastation caused by infestations of the balsam woolly aphid, *Adelges piceae* Ratz.

My studies point out the need for a critical study of the lichens at lower elevations throughout the Southern Appalachians also. Therefore, while essentially completing my original proposed research this coming year, I will be beginning a larger study of the macrolichen flora of the entire Southern Appalachian region.

# # #

SEASONAL FOOD HABITS OF EUROPEAN WILD HOGS (*SUS SCROFA*) IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

INVESTIGATOR: Charles D. Scott

SUMMARY OF PROGRESS: A food habits study of the European wild hog (*Sus scrofa*) was conducted in the Great Smoky Mountains National Park from September 1971 to May 1973. The objective of the study was to determine the seasonal food habits of European wild hogs in the park.

One hundred twenty-eight stomachs were collected by a combination of live-trapping (69 animals) and direct reduction (59 animals). Results were presented by percentage volume and frequency of occurrence. Results were grouped into four seasons: spring (March-May), summer (June-August), fall (September-November), and winter (December-February).

Grasses (Gramineae) were the major food items in the spring. Unidentified green vegetation and oak (*Quercus* sp.) mast ranked second and third, respectively, in total volume of spring foods eaten. Roots were eaten in the least volume during this season. Invertebrates appeared frequently, but in only trace amounts by volume.

Consumption of grasses declined during the summer months, although these foods still made up one-fourth of the total summer volume. Fruits of huckleberries (*Gaylussacia* sp.) and blueberries (*Vaccinium* sp.) were eaten during the late summer. Apples (*Malus* sp.) were a preferred food of hogs in local situations.

Roots were eaten more than any other food during the fall, followed by oak mast and grasses, respectively. Hickory (*Carya* sp.) mast was eaten in lesser amounts than the above foods.

Roots were again the most important food item during the winter months. Oak mast was eaten in greater amounts than during the fall. Grasses were eaten less in winter than any other season.

Plant matter comprised 90.2% of the total volume of foods eaten by hogs during the study period. Roots were the major type of plant food consumed. No discernable trend in seasonal utilization of animal matter was found. Invertebrates were the most frequently eaten animal matter in every season.

Observations of rooting sites were made in order to obtain additional information on hog feeding habits. Field observations should not be relied upon primarily for complete food habits information, however, due to the subjectivity of such evaluations.

Comparisons of food habits information obtained from trapped and shot hogs were made. Both of these methods may be used effectively for food habits studies, depending on the accessibility of an area and seasonal movements of hogs.

European wild hogs are considered to be competitors with some native wildlife for oak mast, particularly in years of low mast production. No evidence of hog predation on the nests of ground-nesting birds was found, and hogs apparently were not significant predators of salamanders or small mammals in the GSMNP. It is hypothesized that hogs root more and thus cause more "damage" to understory vegetation in years of poor mast production.

# # #

SOME ASPECTS OF HISTORY OF THE BLACK BEAR (*URSUS AMERICANUS*) IN THE GREAT SMOKY MOUNTAINS

INVESTIGATOR: Julie D. LaFollette

SUMMARY OF PROGRESS: This study was conducted to assess the factors which have affected the black bear in the Great Smoky Mountains from earliest recorded history until 1960. It was believed that this information might be useful in establishing a long-range black bear management plan in the Great Smoky Mountains National Park. Research into some aspects of National Park Service policy was carried further in order that future recommendations might be made.

Historical data were gathered primarily from written sources. State histories from both North Carolina and Tennessee, diaries, travel logs, biographical sketches, records of defunct companies from the area, and available National Park Service records were used extensively. These were supplemented with photographs, magazine and newspaper articles.

However, many of the articles found in magazines and newspapers proved to be inaccurate and were not used.

Interviews of 186 present and former residents of the area were taken--133 verbal and 53 written. Many of these people hunted black bear in the mountains and/or worked for one of the logging or railroad companies which operated in the district before 1930. No particular format was adhered to when conducting interviews, but many of the same questions were asked each interviewee. Fourteen representative interviews were selected and used as examples through most of the thesis. Other interviewees were quoted only when necessary.

Results were sorted into six major categories--hunting and trapping uses, vegetation changes, depredations, park policy and problems, and biology. Each category was analyzed separately. Within each section, the data were presented chronologically.

It was found that prior to the settlement of the Smokies, there were few limiting factors controlling the Great Smoky Mountain bear population. By 1825 to 1850, the density of subpopulations of bear around scattered settlements had decreased through movement from areas of human occupation, from related vegetation changes, and from hunting. On the whole, the bear population in the Great Smoky Mountains remained unchanged. From 1900 to 1930, over 60% of the area now enclosed in the Great Smoky Mountains National Park was logged, much of it extensively. With this large-scale habitat destruction, the bear population underwent a serious decline. Hunting and trapping further decreased the population. By the late 1920s, bears were found only in the more inaccessible areas.

With the establishment of the Great Smoky Mountains National Park in 1930, and the ensuing wildlife protection in 1934, it appeared that the black bear would eventually return to its original numbers as the vegetation began to mature. However, the chestnut blight, infecting the area since 1925, apparently had a dramatic effect on the bear population. The last good crop of chestnuts in the Great Smoky Mountains National Park was reported in 1938. By 1940, 50% of the chestnuts were dead and another 35% were dying. The 1940s were marked by mast failures within the park, increased bear depredations on the surrounding areas, and a corresponding decrease in the bear population. Data indicate that the bear population continues to fluctuate irregularly due to periodic years of poor mast production. This is also related to increased movements of bears and a concomitant increase in the legal and illegal kill in and around the periphery of the park.

Major problems within the Great Smoky Mountains National Park today are poaching and bear-person interactions. It was found that attitudes among native people living around the park and limited law enforcement within the park are the primary causes of current poaching. Within the park, ignorance and disregard of regulations by the park visitor, as well as the leniency practiced by rangers towards those guilty of minor infractions, eventually has led to conflicts at roadsides, picnic grounds, campgrounds, and trail shelters. A program of education and more strict law enforcement should be initiated for a more successful plan for black bear. The following might be included in such a program.

1. Regular contact with local communities through hunters organizations, garden clubs, farm groups, and schools. Information disseminated might include familiarizing the people with the research, routine work, and goals of the Great Smoky Mountains National Park.

2. Periodic meetings with the National Beekeeping Association, the Tennessee State Beekeepers Association, or the various regional and county affiliates would do much to relieve current misunderstandings. Current methods of prevention of hive raiding and other depredation controls could be discussed.

3. Establishment of a cooperative community program with the Tennessee Wildlife Resources Agency. This program might include (1) and (2) above.

4. Additional displays within the park similar to that at the Sugarlands Visitor Center depicting different aspects of the black bear's history and behavior. Additional visual aids and "talking boxes" would be useful at centers of visitor-bear conflicts.

5. Strict law enforcement for both poachers and visitors. It is very difficult for an already busy ranger to spend the time in the backcountry necessary to control poaching.

Good relations with local people might lead to information that would aid in the capture of illegal hunters. Park visitors, if aware that citations, rather than warnings, were issued for a first offense, might be more observant of park regulations.

6. A system of annual mast indices in order to predict fluctuations in mast and wildlife populations.

7. Attempting to maintain more stability in professional park personnel. The rapid turnover rate tends to make natives feel that they are dealing with "outsiders."

8. Eliminating private inholdings which apparently play a role in giving access to poachers.

9. Eliminating public access to all non-paved roads leading to remote areas in order to help contain poaching.

10. Prevention of construction of new roads, paved or unpaved.

# # #

REPRODUCTIVE BIOLOGY OF THE EUROPEAN WILD HOG (*SUS SCROFA*) IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

INVESTIGATOR: Robert W. Duncan

SUMMARY OF PROGRESS: A study of the reproductive biology of the European wild hog (*Sus scrofa*) was conducted in the Great Smoky Mountains National Park from September 1971 to July 1973. The purpose of this investigation was to gather information on the reproductive biology and population dynamics of the European wild hogs in the park. The results of this study were obtained by the collection and analyses of reproductive tracts, field observations and back-dating ages of hogs to establish periods of reproductive activity.

A total of 162 animals was collected by a combination of live-trapping (89 animals) and shooting (73 animals). Eighty-five females and 77 males were collected for a male:female sex ratio of 52:48. The prenatal male:female sex ratio, based on four fetal litters, was 50:50. Sex and age structure of the European wild hog population in the park was indicative of an expanding population.

Both male and female hogs attained the age of puberty within the first year of life. Epididymal examinations indicated that the male hogs in the park reached sexual maturity between 7.0 and 12 months. Twenty-eight (35.4 percent) males were classified as immature and 51 (64.6 percent) as mature. Females matured earlier than males, reaching puberty between 4.0 and 7.0 months. Sixteen (22.2 percent) of the females were immature, 41 (57.0 percent) were sexually mature and 15 females (21.0 percent) were classified--status undetermined. The size of the females at maturity in this study was found to be smaller than previously reported.

Mature males were physiologically capable of breeding year-round. Females, while capable of farrowing during any month, exhibited peaks in breeding and subsequent farrowing activities.

The average litter size based on fetal counts was 3.0 and the range was from 2.0 to 4.0. Average litter size based on fetal counts, trapped litters, litters observed in the field and the numbers of lactating teats of sows with young was 3.2 with a range from 1 to 5.

Limited data suggest that the concept of a farrowing range may be applicable to the wild hogs of the Great Smoky Mountains National Park.

The major farrowing peaks for the European wild hog in the park were found to be in late fall-early winter (November, December, and January) and late spring-early summer (May, June, and July).

Farrowing, except during periods of critical food shortages, appears to occur once a year. However, limited data suggest that there is a possibility that during years of abundant food supplies, some sows may farrow two litters within a 12-month period.

The fact that 162 wild hogs were collected during the course of the study reflects the ineffectiveness of past and present control programs. The characteristics of the wild hog, coupled with the inaccessibility of certain areas within the park, make the successful control of this species doubtful. Knowledge of the farrowing peaks and the indication of the establishment of farrowing range may facilitate increased efficiency in some control operations.

# # #

AN EVALUATION OF RADIOACTIVE FECES-TAGGING AS A TECHNIQUE FOR DETERMINING POPULATION DENSITIES OF THE BLACK BEAR (*URSUS AMERICANUS*) IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

INVESTIGATOR: Larry C. Marcum

SUMMARY OF PROGRESS: A study to determine the density of a black bear population using radioactively tagged scat was conducted in the Great Smoky Mountains National Park from June through October of 1972 and 1973. The major objectives of the study were: to evaluate the technique of radioactively tagging bears as a means of providing reliable data for population estimates and to delineate the density of the black bear population in the Great Smoky Mountains National Park.

The Great Smoky Mountains National Park consists of 800 square miles of mountainous terrain characterized by a diversity of plant and animal species. There is considerable variability in both temperature and precipitation from areas of low elevation to areas of high elevation. The study area consisted of 200 square miles within the Tennessee portion of the park lying west of U.S. 441.

During the 2-year period a total of 66 individual bears were captured and ear-tagged while 60 of these animals were injected with radioisotopes.

Capture techniques included: free-roaming capture, hog traps, culvert traps, and Aldrich foot snares. In 1973, 199 trap nights resulted in 57 bear visits and 42 captures which yielded a trap nights per capture ratio of 4:6. The technique of prebaiting was believed to be responsible for the high degree of efficiency in trapping.

Two confined bears were injected with 50 uc of ^{65}Zn and ^{54}Mn and ^{109}Cd and ^{144}Ce. Droppings (scat) collected from these bears were analyzed to determine how long and in what amounts the radioactive materials would be excreted. Based on data collected from the above bears, ^{65}Zn and ^{54}Mn were satisfactory as radioactive tags. Both ^{65}Zn and ^{54}Mn appeared to be resistant to leaching in the fecal material and were easily identified and quantified.

Bear scats were collected from previously established index trails and from abandoned and unmaintained trails. One hundred and eighty-nine scats from 655 miles of trails and 240 scats from 950 miles of trails were collected in 1972 and 1973, respectively. In addition, black bear observations by researchers, National Park Service personnel, and backpackers totaled 259 and 117 for the 2 years.

Population estimates were obtained by the Schnabel method using mark-observation data and radioactive-non-radioactive scat data for both 1972 and 1973. Estimates using mark-observation data were 43 and 54 animals, respectively, for the two years. Estimates using radioactive-scat tag data were 102 and 132 animals for the two years. The estimate for 1973 using radioactive tags was believed to be more accurate than for 1972 due to a better distribution of tagged animals.

The black bear density for the study area in 1973 was computed to be 1 bear per 1.06 square miles (680 acres) while areas of higher density within the study area included one 17 square mile area with a density of 1 bear per 0.42 square miles (275 acres) and another 15 square mile area with a density of 1 bear per 0.54 square miles (342 acres).

In attempting to correlate density with certain indices, it was determined that observational indices are probably not suitable as indicators of population trends. The incidence of bear scats on trails as an indicator of population density should be given further study. Prebait utilization by bears also has potential as a suitable index.

The radioactive-tagging technique used to provide data for the Schnabel method appeared to be a much more accurate technique than conventional mark-observe or mark-recapture techniques for censusing the black bear population.

The above appears to be true for several reasons: (1) biases introduced by loss of or failure to recognize tags were completely removed; (2) since the animals did not have to be retrapped, the bias introduced by animals becoming trap shy or trap prone was removed; (3) since bears did not have to be re-observed, the bias introduced by animals becoming habituated to the presence of humans and hence becoming observation-prone was eliminated; (4) since scat were collected randomly over the study area, the bias introduced by non-random recaptures or sightings (specifically the disproportionate number of sightings and captures at trail shelters, campgrounds, and roadsides) was removed; (5) the radioactive-tagging technique tended to generate a large sample size; (6) although difficult to evaluate, it was believed that the radioactive-tagging technique utilized a much greater percentage of the total population in the data collection process; and (7) the radioactive-tagging technique required less expenditures of time and resources in the collection of data when compared to the amount of reliable data obtained.

Radioactive-tagging should prove to be useful for estimating populations of many carnivores since these animals are seldom utilized for food by humans. The technique also has potential for monitoring population mixing, dispersal, movements, and mortality.

# # #

ACTIVITIES AND MOVEMENTS OF THE BLACK BEAR (*URSUS AMERICANUS*) IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

INVESTIGATOR: Larry E. Beeman

SUMMARY OF PROGRESS: Radio transmitters were attached to six bears from 7 August to 7 September 1974 to study fall movements and denning activities. Of the four den sites found during the winter of 1973-74, three were in tree cavities ranging from 10 to 20 meters above the ground (an additional tree den was located in 1972). The fourth den site was a depression excavated by the bear approximately one meter in diameter and 50 centimeters deep under an old stump. These bears entered their dens during December. However, the bear in the ground den site abandoned it in January and was never relocated. Two bears emerged from their dens in the spring during March. The date of spring emergence for the other bears was not determined since their transmitters ceased functioning during the denning period.

To learn more about the fall movements and denning behavior of black bears in the Great Smoky Mountains National Park, six more bears were captured and fitted with radio-transmitters during the summer and fall of 1974. These bears were tracked regularly from 9 September to 22 September and will continue to be located twice a week until denning occurs. An attempt will be made to locate the den sites of these bears. Information concerning den site location and denning behavior will be recorded.

Den sites in trees were further examined after the bears emerged from winter denning. These trees were climbed and data such as tree size and species, height from ground, tree cavity size, forest type of den site and topographical exposure were recorded.

The bear population in the park is being further described by comparing population age and sex structure from year to year. An age and sex structure study can be informative for determining population trends and reproductive potential. Ninety-seven bears have been aged during the last three years by the cementum-annuli technique using the first premolar. This tooth was pulled, sectioned and stained to determine age. Due to the small size of the first premolar, its single root and very likely functionless role, it has proven quite satisfactory as an aging technique without causing any detrimental side effects to the bear.

Since 1970, 74 family groups (sow and cubs) have been observed. From these data, an estimate of litter size has been calculated. Also, a limited amount of data were collected on adult females concerning frequency of litters.

An attempt will be made to better define nuisance bears. Daily movements of three individual nuisance bears were determined and are being analyzed. Also, an evaluation of transplanting nuisance bears as a management tool has been made. This report includes 84 different bears transplanted a total of 156 times. Bears were trapped from one to 13 times and moved from 5.5 to 65 air kilometers. An evaluation of homing ability compared to distance transplanted, season of transplant, age and sex was made. Other parameters of nuisance bears such as size, growth rate and percent of population composed of nuisance animals will be measured.

Information gathered on the movements and activities of bears is presently being organized and all will be presented to the Great Smoky Mountains National Park in thesis form within a few months. These data were collected basically by radio-telemetry although capture and field observational data were useful. A total of 25 transmitters were placed on 19 different bears from June 1972 to present.

For bears on which sufficient data are available, the home range will be outlined by connecting outlying points of location. This method (minimum area method) enables a visual display of ranges. Also, this method aids in describing the social organization of the black bear, i.e., exclusive or overlapping home ranges. Habitat preferences of black bears will be determined by describing the percent of time different bears spent in various forest types. From these data an attempt will be made to better define the seasonal habitat requirements of the black bear in the Great Smoky Mountains National Park. Additionally, several bears were continuously radio-tracked (one reading per hour) for 24-hour periods to determine times of activity and inactivity during diel periods.

To expedite the burdensome task of plotting by hand the hundreds of bear locations recorded by telemetry, a computer program was developed. This program uses trigonometry functions to give X, Y coordinates for each bear location. These coordinates are then given to the "calcomp plotter" which plots the location and Julian date of each bear location.

# # #

SOME ASPECTS OF THE LIFE HISTORY OF THE RACCOON (*PROCYON LOTOR*) IN CADES COVE, THE GREAT SMOKY MOUNTAINS NATIONAL PARK, 1973-74

INVESTIGATOR: William E. Keeler

SUMMARY OF PROGRESS: Traps were set on 114 different nights during the period 27 January 1973 through 16 April 1974 for a total of 2870 trap nights. The total number of animals captured was 553 of which 217 were raccoons. The overall trapping success was 1 raccoon per 13.23 trap nights or 7.56 percent. There were 106 raccoons recaptured. The 111 individual raccoons captured consisted of 48 males and 63 females.

During the study 60 striped skunks and 2 spotted skunks were captured. The sex of 7 striped skunks was determined to be 3 males and 4 females. A total of 54 opossums were captured; the sex of 28 was determined to be 15 males and 13 females. Eleven gray fox and 29 groundhogs were also captured. The remaining 180 animals captured consisted of gray and red squirrels, crows, blue jays, rabbits, and cotton rats.

The sex ratio for the total number of raccoon captures during the study was 111 males to 106 females (1.049 males: 1 female). The sex ratio for 111 individual raccoons captured was 48 males to 63 females (.763 males: 1 female).

In April 1973 an epizootic of canine distemper occurred in the Cades Cove raccoon population. The impact of this disease upon the population is reflected in the decline in percent raccoons captured from an average of 22.17 for Janaury, February, and March 1973 to 5.83 for the same period in 1974.

Using the "frequency of capture" method of population estimation it was possible to estimate the number of raccoons present in Cades Cove before the epizootic at 251 (one per 9.6 acres or one per 4.0 hectare). The population estimate for the same period in 1974, after the epizootic, was 82 raccoons (one per 29 acres or one per 11 hectare).

A comparison of methods of population estimation shows an average decline in numbers of raccoons during the post-epizootic period of 82 percent.

A final report of the study is presently being prepared and will be completed by December 1974.

# # #

AGE DETERMINATION AND AGE STRUCTURE OF THE EUROPEAN WILD HOG (*SUS SCROFA*) POPULATION IN EAST TENNESSEE

INVESTIGATOR: Tom C. Henson

SUMMARY OF PROGRESS: This project is being financed by the Tennessee Wildlife Resources Agency and is scheduled for completion by December 1974. Data (age) gathered from the hog population in the Great Smoky Mountains National Park are being utilized and represent only a part of the overall research project. Work to date has been restricted to laboratory assessment of potential aging techniques for the European wild hog. These include various sectioning and staining techniques, eye lens weight, use of infrared photography on tooth sections, etc. If a valid aging technique is divised, then the age structure of the hog population in the park will be constructed.

# # #

EUROPEAN HOG PROJECT

INVESTIGATOR: Dwight Flynn

SUMMARY OF PROGRESS: Field work on the European wild hog project continued through this time period at a much reduced pace. A total of 50 collecting trips were made to Cades Cove during this period. Nine females and 12 male hogs were collected.

University of Tennessee personnel observed 26 hogs in Cades Cove in addition to the ones listed above. Total killed and observed during the reporting period was 47 hogs.

One study presently underway for special problems credit (Wildlife and Fisheries Science 5110) is based upon spleen weight and length and adrenal gland weight in relation to total body weight and age class. The purpose of this study is to establish a base for future studies on biological and environmental stress. Data has been collected and is now being analyzed. A written report will be presented by 1 January 1975.

# # #

(A) APPLICATION OF RADIOISOTOPE FECES TAGGING AS A TECHNIQUE FOR POPULATION ESTIMATION OF BLACK BEARS (*URSUS AMERICANUS*) IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

(B) THE USE OF RADIOISOTOPES AS A TECHNIQUE FOR DETERMINING THE DISTRIBUTION, DISPERSAL, AND MOVEMENTS OF THE BLACK BEAR IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

INVESTIGATORS: (A) Dan Eager
(B) Louis Eubanks

SUMMARY OF PROGRESS: Black bear trapping was conducted throughout the late spring and summer of 1974. The primary purposes of the trapping program are to estimate the population of bears within the study area and to obtain data regarding movements and home range. All bears captured were measured, weighed, injected with either Zn-65 or Mn-54 isotopes, or both, lip tatooed, and equipped with eartags, if this had not been done previously. Also, a premolar was extracted from most bears for the purpose of aging. Bears were immobilized by the use of either M-99 (Etorphene) or Sernylan, injected with a capture gun. Bear trapping was begun on Bote Mountain on 10 May 1974 where six prebaits were located. More prebaits were established during trapping, until, on 26 May a total of fifteen had been put out. Traps were first set on 19 May and activated on weekends until 6 June. This early trapping resulted in no capture of bears in a total of 37 trap nights.

Full-time trapping was begun on Bote Mountain on 10 June. At this time there were a total of nine snares set and six additional prebaits. Trapping was conducted continuously until 29 June, when traps on Bote Mountain were closed. A total of 126 prebait nights and 195 trap nights were amassed, resulting in the capture of 15 bears, and 3 recaptures. The resulting trapping efficiency was one bear per 10.8 trap nights.

Trapping was carried out on an abandoned trail between Bote Mountain and Defeat Ridge from 1 July until 12 July 1974. In this operation a total of 74 prebait nights and 74 trap nights were accumulated resulting in the capture of three new bears, and five captures of bears previously trapped this summer. Trapping success in the Defeat Ridge area was one bear per 9.25 trap nights.

On 15 July 1974, prebaits were established along Rabbit Creek Road between Abram's Creek and Scotts Gap. Traps were closed on 25 July 1974. In 60 prebait nights, and 24 trap nights a total of five bears were captured with no recaptures. The trapping efficiency was one bear per 4.8 trap nights.

The next area trapped was along the Bent Arm Trail, during the period from 29 July until 8 August. During this time 54 prebait nights and 22 trap nights were compiled in the trapping of three bears. Trapping success in this area was one bear per 7.33 trap nights.

Prebaits were established on the upper portion of Miry Ridge and along the Appalachian Trail to the Derrick Knob Shelter on 12 August. Trapping continued in this area until 22 August, resulting in the capture of three bears. Twenty-six trap nights and fifty-eight prebait nights were amassed, and the resulting trapping efficiency was one bear per 8.67 trap nights.

On 2 September trapping was resumed along Bote Mountain road. The primary purpose of this trapping was to collar the bears with radio transmitters. This was done both to gain information as to movements and home range of black bears, and to follow the animals to their den sites later in the fall. Fifty-three prebait nights and fifty-eight trap nights resulted in the capture of four bears. Of these four, two were previously untagged bears and two were recaptures from this summer. Trapping efficiency was one bear per 14.5 trap nights.

On 2 days during the summer, roadside captures of problem bears were undertaken. On 27 August, a sow with three cubs was captured on Clingman's Dome Road. On 5 September, another sow, with no cubs, was captured. All five animals were taken to Little Cataloochee where they were released.

Postcards for reporting bear observations were distributed to some users of backcountry areas at the Sugarlands Visitor's Center by National Park Service personnel throughout the summer. Of the cards handed out after 5 May, 55 were returned. The total number of bears reported by means of mail-in cards was 81. Of these, ear tags were observed on 10, and no tags were reported on 71. Additional observations of bears throughout the summer brings the totals of 20 tagged and 124 untagged animals. These data will also be used as a means of estimating the bear population within the study area.

The primary means of population estimation will be through the use of radioactive isotope injections. The isotopes are eliminated in the feces (scat), and can be detected by means of counters available at Oak Ridge National Laboratory. Scat collected both on index trails and off the trails will be dried and counted. With the data gathered, a ratio will be established to estimate the population. An attempt will be made to correlate this information with possible indexes to the bear population in the park in the hope that future estimates may be made without the necessity of trapping.

Six index hikes (10 trails) were walked at 2-week intervals from 8 June 1974 through 5 October 1974. These hikes were (1) Mount Collins, (2) Elkmont-Bent Arm, (3) Tremont-Derrick Knob, (4) Spence Field, (5) Gregory Bald, and (6) Hannah Mountain. One hundred and fourteen bear scat were collected.

# # #

FOOD HABITS OF THE LARGER MAMMALIAN PREDATORS IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

INVESTIGATOR: Carter Davis

SUMMARY OF PROGRESS: Predator scat from red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), and bobcat (*Lynx rufus*) were collected from six index hikes (10 trails) at 2-week intervals for the summer of 1974. The six index hikes were (1) Mount Collins, (2) Elkmont-Bent Arm, (3) Tremont-Derrick Knob, (4) Spence Field, (5) Gregory Bald, and (6) Hannah Mountain. Three hundred and thirty-four scat were collected from 8 June through 5 October 1974. An additional 25 to 30 scat were collected from other trails by fellow graduate students working on the black bear study.

Predator-killed mice, shrews, and moles were also collected when found for use as reference material when analysis of food content of the scat begins.

The Mount Collins and Tremont-Derrick Knob index trails have consistently produced high frequencies of occurrence of predator scat (1.06 and 0.444 scat/mile, respectively). These two trails will be walked at 2-week intervals from October 1974 through August 1975. Additional index trails may also be walked during this same period (time permitting). Predator scat collected over a 1-year period should reveal seasonal variations in food habits of the predators.

A predator food habits study of bobcat (*Lynx rufus*), red fox (*Vulpes vulpes*), and gray fox (*Urocyon cinereoargenteus*) would be more scientifically important if the prey species could be definitely correlated with a particular predator. This is difficult to do using the techniques of scat analysis because there is no known way of definitely differentiating bobcat and fox scat. It would be valuable to try to determine if consistent differences occur between scat of bobcat and fox. This could be done by isotope-tagging animals trapped in an area, using a different isotope for bobcat (e.g., Zn-65) and fox (e.g., Mn-54). Trapping and tagging along an index trail such as Mount Collins-Sugarland Mountain, an area that produces a large amount of scat (1.06 scat/mile), could generate a suitable number of known scat for detection of any characteristic differences between the droppings of bobcat and fox. Animals will be live-trapped in large wire traps, anesthetized, and injected with an isotope and released. This study would be undertaken as a Special Problem (Forestry 5110) for course credit. The results could also be incorporated into the thesis on predator food habits.

# # #

ADDENDUM: ANNUAL REPORT TO GREAT SMOKY MOUNTAINS NATIONAL PARK AND GREAT SMOKY MOUNTAINS NATIONAL HISTORY ASSOCIATION ON WILDLIFE RESEARCH ACTIVITIES, 1974

SUMMARY OF PROGRESS: From 5 August to 21 September 1974, an intensive effort was made to collect as much backcountry scat of black bear as possible. The most productive method was to search around trapsites that had produced at least two bear captures. Three or four ridges to the left and the right of the trapsite were searched thoroughly by walking across the area, each time going approximately 50 ft further down the ridge. When scat became increasingly more difficult to find or vegetation such as thick rhododendron or mountain laurel prevented a thorough search, the procedure was abandoned. An area from 0.25 to 0.50 mile from the trapsite was searched in this manner. This method was used at three trapsites on Bote Mountain Road, one trapsite on Andy McCully Ridge, and one location on Sugarland Mountain.

Game trails were followed when possible and proved to be a good source of backcountry scat. Game trails were especially productive in areas that were considered good bear habitat. One non-maintained trail, Defeat Ridge-Rocky Top Trail, was walked every 2 weeks. This trail produced 14% of the total backcountry scat and could possibly serve as an indicator for backcountry scat.

Approximately 90% of the time in the field was spent in the Bote Mountain-Defeat Ridge area. Other time was equally divided between Andy McCully Ridge and the lower half of Sugarland Mountain.

A total of 233 backcountry scat were collected and labeled with the date and exact location. One hundred and two hours in the field yielded 233 scat, or slightly more than 2 scat per hour. All backcountry scat are being dried and then will be analyzed for radioactivity at Oak Ridge National Laboratory. Movement and dispersal data will be determined by the location of the radioactive scat.

While searching for backcountry scat, five black bear daybeds were located. Measurements of the daybeds were taken as well as a general description of the area.

On 12 September, two penned bears at Tremont, Kate, and Teddy were injected with 100 microcuries of two new isotopes Cesium-134 and Cobalt-60 respectively. Scat were collected every other day for one week, every third day for another week, and is continuing to be collected once a week at present. These scat will be analyzed later this fall at Oak Ridge National Laboratory to determine the feasibility of using Cesium-134 and Cobalt-60 for radioactive feces-tagging.

Throughout the summer, blood samples were taken from 26 bears (10 female and 16 male) captured in snares. One of these bears, suspected of having a possible liver infection, was later recaptured and another sample taken. Results from the second sample revealed that the bear no longer had an infection.

Fifteen cc of blood were drawn from the femoral vein of each bear, centrifuged, refrigerated, and the serum taken to the Clinical Laboratory at the University of Tennessee Hospital. This study is in cooperation with Jim Sparks, Head Clinical Diagnostic Laboratory, University of Tennessee Hospital.

In addition to the 26 bears mentioned above, blood samples were also taken from two female bears that were removed from Clingman's Dome Road and two penned bears (one male and one female) at Tremont.

At the University of Tennessee Hospital the serum samples were analyzed on an SMA-12 and SMA-6 auto-analyzer. The SMA-12 test includes the following parameters: total protein in the serum, albumin, calcium, phosphorus, cholesterol, uric acid, creatinine, total bilirubin, alkaline phosphatase, creatine phosphokinase, lactate dehydrogenase, and aspartate aminotransferase. The SMA-6 test included chloride level, CO_2 level, sodium, potassium, blood urea nitrogen, and glucose. In addition to the SMA tests, serum protein electrophoretic tests were also run for specific blood proteins.

Thus a total of 30 blood samples have been collected and analyzed.

# # #

QUALITATIVE AND QUANTATIVE ASPECTS OF THE FOOD HABITS OF THE EUROPEAN WILD HOG IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK.

INVESTIGATOR: Susie Matthews

SUMMARY OF PROGRESS: During the year, contents of 75 gastrointestinal tracts of European wild hogs collected in the park were sampled. Each sample was labeled (specimen number, kill date and location, and specific section of intestinal tract sampled) and oven-dried at 60°C. Duplicate specimens were placed in 10% formalin solutions and similarly labeled.

One trip was made to Derrick Knob and the immediate vicinity to collect plant specimens from the northern hardwood forest. These plants were collected, returned to the lab and oven-dried at 60°C.

Each plant was then separated into leaf, stem, root, and flower sections. Each section was individually ground (Wiley Mill) over a 20 mesh screen and placed in jars (labeled as to species, part of plant, and date collected).

Slides are presently being prepared for each part of each species of plant. These slides will constitute the beginning of a reference collection of plants from the northern hardwood forest. Continued collections of plants from this area (seasonally) will allow for inclusion of the majority of species found.

A literature review pertaining to the subject, methods, and procedures used has also been completed (Table 9).

During the summer a total of over 40 fecal samples (scat) of hogs were collected in the northern hardwood areas of the park. These samples represent a beginning collection of food materials consumed by hogs from this forest type and will be analyzed microscopically for exact plant species content (qualitative and quantative). Using the reference collection of microscopically prepared slides of plants it is hoped that an accurate estimate of foods consumed by hogs can be derived.

Table 9. SOME LITERATURE REVIEWED FOR THE MICROSCOPIC FOOD HABITS STUDY OF THE EUROPEAN WILD HOG IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

Baker, E. W., and G. W. Wharton. 1952. An introduction to acarology. Macmillan Co. New York. 465 p.

Baumgartner, L. L., and A. C. Martin. 1939. Plant histology as an aid in squirrel food habit studies. *J. Wildl. Manage.* 3(2):266-268.

Jones, P. 1959. The European wild boar in North Carolina. Game Division, North Carolina Wildl. Resources Comm., Raleigh. 186 p.

National Park Service. 1969. Resource Management plan for the Great Smoky Mountains National Park. Gatlinburg, Tennessee. 186 p.

Scott, C. D. 1973. Seasonal food habits of European wild hogs (*Sus scrofa*) in the Great Smoky Mountains National Park. M.S. Thesis. University of Tennessee. 54 p.

Sparks, D. R., and J. C. Malecheck. 1968. Estimating percentage dry weight in diets using a microscopic technique. *J. Range Manage.* 21(4):264-265.

Tennessee Game and Fish Commission. 1972. European Hog Research Project W-34. Final Report. 259 p.

Additional new research. 1. Relationships between body weight and measurements and sex and age of black bears in the Great Smoky Mountains National Park.

Data on over 100 bears are presently being analyzed for influence of sex and/or age on body weights and measurements.

2. Influence of various human odors on behavior of caged bears.

Various human odors (urine, menstrual fluid, etc.) are being presented to penned bears at Knoxville Zoological Park and Tremont Environmental Educational Center. Behavior reactions to these presentations are being recorded.

3. Dietary competition among herbivores and omnivores in the Great Smoky Mountains National Park.

This study will be under the direction of Boyd Dearden, wildlife biologist and systems ecologist in our department. The study proposes to develop a simulation model to determine the flow of energy (or biomass) through and the dietary interaction of selected herbivores and omnivores in the park.

Publications and/or Presentations

Beeman, L. E., and M. R. Pelton. 1974. Homing of black bears in the Great Smoky Mountains National Park. Third International Conference on Bear Research and Management. Binghamton, New York, and Moscow, USSR.

Beeman, L. E., M. R. Pelton, and L. Marcum. 1974. Use of M99 Etorphine for immobilizing black bears. *J. Wildl. Manage.* 38(3) (In Press).

Beeman, L. E., and M. R. Pelton. 1974. Seasonal food habits of black bears in the Smoky Mountains of Tennessee and North Carolina. *J. Wildl. Manage.* (In Press).

Marcum, L. C., M. R. Pelton, and L. E. Beeman. 1974. A preliminary evaluation of the use of foot snares for the capture of black bears. Third International Conference on Bear Research and Management. Binghamton, New York, and Moscow, USSR.

Pelton, M. R. 1974. Population studies of the black bear in the Great Smoky Mountains National Park. Third International Conference on Bear Research and Management. Binghamton, New York, and Moscow, USSR.

Scott, C. D., and M. R. Pelton. 1974. Attitudes and opinions of persons experiencing property damage or injury by black bears in the Great Smoky Mountains National Park. Third International Conference on Bear Research and Management. Binghamton, New York, and Moscow, USSR.

FUTURE RESEARCH: Black bear. 1. Continued trapping and tagging in the present study area using radioisotopes and radio collars.

2. Continued hiking of index trails for droppings.

3. Continued distribution of postcards to backpackers for observation records.

4. Denning and winter activities studies.

5. Characteristics of the negative foraging period.

6. "Wild" vs "Panhandler" bear behavior and ecology.

7. Movements and dispersal of yearling bears.

8. Population study of bears on the North Carolina side.

9. Movements and activities during the "Fall Shuffle."

10. Influence of backcountry camping on black bear behavior and activities.

European wild hog. 1. Continued accumulation of biological data from animals (e.g., weight, age measurements, reproductive tracts, etc.).

2. Telemetry of radio-collared hogs.

3. Density estimates through a tag and harvest study.

Other wildlife species. 1. Telemetry study of raccoons and white-tailed deer in Cades Cove.

2. Density and distribution study of white-tailed deer in Cades Cove.

# # #

PROGRESS REPORT ON GREAT SMOKY MOUNTAINS NATIONAL PARK GRANT
THIRD QUARTER REPORT FOR THE PERIOD 1 JANUARY TO 30 MARCH 1974

SUMMARY OF PROGRESS: This report covers the work accomplished on the macrobenthic invertebrate acid pollution study carried out by the Aquatic Biology Group according to the agreements contained in Purchase Order No. PX500031672 from USDI, National Park Service, Southeast Regional Office. All activities associated with the program were conducted in conjunction with the Department of Biology and the Tennessee Cooperative Fishery Unit at Tennessee Technological University, Cookeville, Tennessee.

As outlined in the first quarter report for the study period 1 June to 30 September 1973, the four components of the project were outlined and discussed; and the initial work started on each component. During the second quarter, work was continued on components (1), (2), (3), and (4) and, in addition to some minor additions and deletions to the components during this period, a fifth (5) component, that involving computer techniques for analysis, was included.

In this third quarter, further work was completed on components (2) through (5). Sampling and collecting were incompletely accomplished during the January and February periods because of "high" water. No problems are anticipated for the March period that falls on the date this report is due.

MATERIALS AND METHODS: Water Quality Parameters. Water quality samples were collected at each station by submerging a 0.50 gal. glass jar below the surface at midstream, transported from the field to the laboratory in ice, and analyzed within 15 hours after collection. Alkalinity, pH, calcium hardness, sulfates, and turbidity were determined by use of a Hach Direct Reading Engineer's Laboratory Kit (Hach Chemical Co., Ames, Iowa). Stream temperature was obtained with a mercuric thermometer, and conductivity was measured with a Beckman conductivity bridge (Beckman Instruments, Inc., Cedar Grove, New Jersey). In addition water samples were collected at each of the stations 4.7 and 4.6 on 5 January 1974, between 1:00 and 5:00 p.m. (EDST). Samples at stations 3.5 and 0 were collected on 6 January 1974, between 9:00 and 11:00 a.m. (EDST). Additional parameters, including acidity and dissolved oxygen, were obtained from a second series of samples collected from the same four stations on 2 February 1974, from 1:00 and 5:00 p.m. (EDST). Acidity and dissolved oxygen were determined by standard methods (American Public Health Association 1965).

Benthic Macroinvertebrate Collections. Two qualitative and two quantitative macroinvertebrate samples were collected from ecologically similar riffle areas at stations 4.7 and 4.6. Due to high water conditions, three qualitative and no quantitative samples were collected at stations 3.5 and 0. All samples were taken in an upstream direction rather than in a cross-stream direction due to the smallness of the stream. The qualitative macroinvertebrate samples were collected by a 1-minute kick method using a Turtox long handled bottom net measuring (8 X 10 X 18 inches) during continuous disruption of the substrate caused by kicking the area immediately above the net as discussed in the second progress report. Quantitative sumples were collected using the Surber square foot sampler. Equal collecting effort was expended at each ecologically similar site. In the laboratory, the macroinvertebrates were separated from the debris using a sugar flotation technique, preserved in 95% ethanol, identified to the genus level where possible using the appropriate keys, and counted.

Proposed Study Plan for the Fourth Quarter and Final Report. Monthly sampling will continue through 31 May 1974, and be processed in a similar manner as discussed in the text above. All macroinvertebrate information will be processed by a computer program for developing diversity indexes and comparisons between stations. Intensified studies of organism drift and colonization rates for macrobenthic to artificial substrate samplers are anticipated.

R. Lynn Green is now registered in graduate school and will continue the field and laboratory studies to completion.

# # #

FOREST COVER AND STAND VOLUME ESTIMATES PRIOR TO AND FOLLOWING DISTURBANCE IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

INVESTIGATORS: Edward Buckner) University of Tennessee
Weaver McCracken)

SUMMARY OF PROGRESS: Work has progressed as planned on the first three phases of the study as outlined in the original work plan. An overview of previous logging activities in the park area has been completed and two watersheds selected for intensive study. All of the study sites in the Tremont area have been identified and ground studies are in progress. Pictures and taped descriptions of the original condition and the nature and extent of disturbance have been obtained. The final work under phase III should be largely completed over the Christmas Holidays (1974).

# # #

BRYOPHYTES OF THE GREAT SMOKY MOUNTAINS

INVESTIGATOR: Aaron J. Sharp
University of Tennessee

SUMMARY OF PROGRESS: A few collections were made, mainly on the Ramsey Cascades trail. All were duplicates of species previously collected but it showed that two very rare species, *Homalia jamesii* and *Acrobolbus ciliatus* (*A. rhizophyllus*) were maintaining themselves in the park. It also established that *Anacamptodon splachnoides* would grow on shaded, vertical surfaces of graywacke boulders, the only known locality; otherwise it is known only from treetrunks, usually in and around knotholes.

# # #

HYBRIDIZATION OF *TRILLIUM* SPECIES

INVESTIGATOR: Alan B. Adams
University of Tennessee

SUMMARY OF PROGRESS: I collected approximately 30 *Trillium* within the park. It appears that *T. cuneatum* and *T. lateam* are hybridizing around Fontana but a hybrid plant has not yet been seen in the park. I have not found *T. cuneatum* within the park boundaries to date.

Chemical work in progress with flavonoids.

# # #

WATER RESOURCES OF DOG CANYON (UPPER) GUADALUPE MOUNTAINS NATIONAL PARK CULBERSON COUNTY, TEXAS

INVESTIGATOR: Dustin M. Aughenbaugh

OBJECTIVES: To appraise the water resources of Upper Dog Canyon with particular emphasis on the availability and suitability of the groundwater resources.

METHOD: Compile all available geo-hydrological and geological studies, data, and information of the immediate and surrounding area; extend the depth of the existing 350-ft test well for local verification of the character of the area; and prepare a comprehensive water resource report.

RESULTS: An investigation of the water resources for Upper Dog Canyon resulted in little or no dependable supplies of surface water being available. Flow from seepages and springs range less than 1.5 gpm (estimated) and wildlife depends on these supplies. The only runoff supply, located northwest of the Ranger's Station, is intermittent and undependable; being runoff from the local rainfall. Back in the 1960s, a 500-ft test well was drilled on the west side of the canyon about 0.25-mile south of the Ranger's Station; the exact location is unknown. The well tested the alluvium and the goat-seep limestone, but failed to obtain any water. At the end of 1974 a dry test well was drilled 975 ft to refusal into the goat-seep limestone on the east side of the canyon. As of this date (January 1975) a second test well is being drilled to 1300 ft into the limestone formation in the pasture north of the Ranger's Station. According to the data from Spiegel Well No. 1, the regional water level in this area is just below 1000 ft where a probable adequate water supply may be available. The Spiegel Well, drilled as an oil well some distance north of Dog Canyon, was converted into a 1200-ft water well and provides sufficient quantities (est. 20-60 gpm) of low-mineralized water (sulfates less than 250 mg/l). However, the water is reported undesirable as drinking water due to possible contamination by the oil well casing.

CONCLUSIONS: The data that is available indicates that a well drilled into the regional water table is the most likely source of water.

PLANS FOR 1975: Continue to drill the present test well to 1300 ft or into the regional water table of the goat-seep limestone formations at approximately 1500 feet.

Bibliography

Pratt, Wallace E. 1971. A letter report to Edward R. Leggat on Guadalupe Mountain National Park.

Leggat, E. R. 1972. A memorandum report of 26 May 1972 on water resources of Pine Canyon and Dog Canyon titled, Test Well in Pine Canyon.

# # #

THE BIONOMICS OF *POGONOMYRMEX MARACOPA* WHEELER (HYMENOPTERA: FORMICIDAE) IN GUADALUPE MOUNTAINS NATIONAL PARK

INVESTIGATORS: James V. Moody) Texas Tech University
David E. Foster)

SUMMARY OF PROGRESS: Introduction. Harvester ants are a conspicuous feature of the Guadalupe National Park landscape. Perhaps the most noticeable is *Pogonomyrmex* *maracopa* Wheeler, which inhabits the valley floors throughout the park.

Harvester ants are of special ecological interest because of their ability to maintain viable, large populations in habitats that are severe and inhospitable to many forms of insect life.

A number of workers have studied harvester ants with the objective of control or eradication. The bionomics of a related species, *Pogonomyrmex occidentalis* (Cresson), has been studied (Lavigne 1969; Rogers 1974). The only published work on *P. maracopa* (Ettershank and Whitford 1973) deals specifically with oxygen consumption under laboratory conditions.

A study was initiated in 1974 to examine the bionomics of *P. maracopa* in the valley floor habitats of Guadalupe National Park, to be conducted in two phases. Phase one, presently underway, is a study of nest and colony activities, including nest structure, reproductive cycle, forage behavior, and the effect of abiotic factors on foraging. Phase two will focus on the energetic requirements of this species.

Study Area. The study area chosen for phase one is the floor of West Dog Canyon along the northern boundary of the park. The site was chosen for the following reasons: its vegetable cover approximates that found on most valley floors within the park; it has numerous ant colonies; a deep ravine runs through the center of the site that facilitates excavation of adjacent colonies; and it has relatively easy accessibility.

METHODS: Observations were made and colonies were excavated during April, May, June, July, August, and October 1974. Colonies chosen for excavation were located within 5 ft of a ravine. They were reached by digging laterally from the wall of the ravine toward the colony. Nest structure was mapped and the number of eggs, larvae, pupae, workers, and inquilines in each chamber was recorded.

Forage activity periods and rates were determined by selecting three colonies to be observed at hourly intervals during their above-ground activity period each day. The number of foraging ants returning to the mound during a 5-minute period at hourly intervals was counted.

Forage materials gathered were determined by aspirating each returning forager into an empty vial. Aspirated ants generally responded by dropping their booty. The booty of each ant was placed in a separate envelope. One hundred returning ants were taken during the July, August, and October study periods. Forage materials were separated into six categories: dry twigs, dirt and pebbles, seeds, parts of living plants, animal parts, and bird feces.

Forage patterns and overlaps among adjacent colonies were studied by following the movement of individual workers and marking their maximum distance from the nest until a consistent foraging pattern was established for the colony.

The influence of abiotic factors on above-ground activity was observed during all phases of the study. Initial observations suggested that above-ground activities of *P. maracopa* are influenced largely by temperature.

RESULTS AND DISCUSSION: The most obvious feature of the nest, the dome-shaped mound and the first 12-16 inches below it, are honeycombed with dome-ceilinged, flat-floored chambers. Below the honeycomb area, two or three main vertical shafts extend downward to a depth of 42-78 inches below the mound entrance. The distance between chambers along the first foot of the vertical shafts is usually less than 2 inches. At lower depths, the chambers are separated by as much as 10-12 inches. Vertical shafts usually come to a deadend, but sometimes merge with an adjacent shaft. The largest chambers were found in the mound and near the bottom of the nest.

Mound and nest size correlate roughly with the age of the colony and the number of workers present. However, the fact that colonies have been observed moving into abandoned nests detracts from the predictability of the relationship.

Nests of about equal mound size were selected for excavation. The total number of individuals per excavated colony are given in Table 1.

Foraging activity appears primarily dependent on temperature. The nest entrance is usually uncovered and the first workers emerge when the surface of the mound reaches 21-23°C. Activity increases until the surface temperature reaches 28-30°C and then starts to decrease. At temperatures of 46°C and above, activity is reduced greatly. It ceases when temperatures go above 57°C. Morning foraging was terminated usually by 11:00 a.m. MST. Afternoon foraging begins when temperatures drop to the 48-52°C range, increases in frequency until temperatures drop below the mid-thirties, then decreases rapidly. Activity ceases when temperatures drop to the upper twenties. The bimodal pattern of daily activity described herein does not occur on days when maximum temperatures do not exceed the lower thirties. Other abiotic variables such as relative humidity, light intensity, and barometric pressure were not accounted for.

Foraging patterns suggest that colonies forage from their mound in all directions. They leave the bare area surrounding the mound by fairly well-defined routes, which lead in all four directions. Beyond the margin of the bare area, foraging appears to become random. Forage distances extend at least 14 m from the nest entrance. However, many excursions never extend beyond 5 or 6 m from the entrance and are terminated when the first acceptable booty is encountered. Materials returned by foraging workers are itemized in Table 2.

Insect parts comprised a substantial part of the forage material only after the initial summer rains, which trigger a flush of insect emergence.

Experiments now underway will be continued during 1975 and expanded to obtain data on the dry weight of organic material returned to the nest and the proportion of available material actually utilized. The distribution of colonies within the study area and the interaction of adjacent colonies will be examined. The effects on foraging activity of relative humidity, barometric pressure, and light intensity as well as temperature will be measured and their relative effects analyzed.

Table 1. POPULATION OF *Pogonomyrmex maracopa* NESTS EXCAVATED DURING 1974

	April 20	May 11	June 9	July 9	August 7	October 19
Eggs	40	121	73	103	3	0
Larvae	51	328	278	1331	470	46
Pupae	0	0	83	1104	393	0
Workers	13,816	5932	1505	3148	3442	2958
Total	13,907	6381	1939	5789	4308	3004

Table 2. MATERIALS RETURNED BY FORAGING ANTS AT WEST DOG CANYON, 1974

	July 9	August 3	October 18
Twigs	7	25	28
Dirt and Pebbles	1	43	7
Seeds	54	29	62
Parts of Living Plants	3	0	0
Athropod Parts	35	3	2
Bird Feces	0	0	1
Total	100	100	100

References

Ettershank, G., and W. G. Whitford. 1973. Oxygen consumption of two species of *Pogonomyrmex* harvester ants (Hymenoptera: Formicidae). *Comp. Biochem. Physiol.* 46:605-611.

Lavigne, R. J. 1969. Bionomics and nest structure of *Pogonomyrmex occidentalis* (Hymenoptera: Formicidae). *Ann. Entomol. Soc. Am.* 62:1166-1175.

Rogers, L. E. 1974. Foraging activity of the western harvester ant in the short grass plains ecosystem. *Environ. Entomol.*, in press.

# # #

RECENT MOLLUSCA OF GUADALUPE MOUNTAINS NATIONAL PARK, TEXAS

INVESTIGATOR: Richard W. Fullington
Dallas Museum of Natural History

SUMMARY OF PROGRESS: Progress of the Recent Mollusca survey has gone quite well, although only major places in the mountain range have been sampled thus far.

One fresh-water pelecypod species, three fresh-water gastropod species, and thirty-eight land gastropod species have been collected during this survey. Eight of these species (all land) are either first reports for Texas, or were previously known only as fossils in Texas. Perhaps the most significant item, thus far, is the finding of mixed colonies of separate species that, with further study, may lead to the solution of several sticky taxonomic problems. Several ecological and taxonomic problems relating to North American mollusks are to be found in the Guadalupe Mountains molluscan fauna. In view of this fact, the Guadalupe stands as an exceedingly strong area for taxonomic and ecological molluscan research. Details will be presented in a more comprehensive report.

The Guadalupe Mountain Recent Mollusca survey should be carried to its completion at the current rate of investigation.

# # #

BREEDING AVIFAUNAS OF WOODLAND COMMUNITIES
GUMO-N-0012

INVESTIGATOR: George A. Newman
Hardin-Simmons University and Texas A & M University

SUMMARY OF PROGRESS: My field investigations of breeding birds within the Guadalupe Mountains area began in the summer of 1969 and continued each summer through 1974. In the summers of 1969, 1970, and 1971 my work consisted primarily of initial surveys including limited specimen collecting. Periods of about 2 weeks were spent in the field during late May and early June of these first 3 summers. Funding for the initial investigations was received from the Carlsbad Caverns Natural History Association (1969) and the Frank M. Chapman Memorial Fund of the American Museum of Natural History (1970, 1971).

In the summer of 1972 I began taking extensive data on breeding bird populations from established census plots in Main McKittrick Canyon, and the Bowl. Five to six weeks were spent in the field each summer from late May to early July in 1972, 1973, and 1974. Full funding for my research these past 3 summers was granted by the Rob and Bessie Welder Wildlife Foundation in the form of a scholarship to support my doctoral studies in the department of wildlife science at Texas A & M.

A complete report dealing with all of my findings will be presented at the symposium on biological investigations of Guadalupe Mountains National Park, which is to be held on the Texas Tech University campus in April 1975.

# # #

LATE PLEISTOCENE BIOTIC COMMUNITIES OF THE GUADALUPE MOUNTAINS, TEXAS

INVESTIGATORS:
Thomas R. Van Devender)
Paul S. Martin)
Arthur M. Phillips, III) University of Arizona
W. Geoffrey Spaulding)

SUMMARY OF PROGRESS: Deposits of perishable organic materials preserved in caves of the Guadalupe Mountains are providing rich records of the late Pleistocene biotic communities in west Texas. These deposits are being excavated and studied with permission and support of the National Park Service and the Guadalupe Mountains National Park. Studies of dung of the extinct Shasta ground sloth (*Nothrotheriops shastense*) and plant macrofossils from William's (or "Indian") Cave and three additional caves are reported in a paper entitled, Late Pleistocene Biotic Communities from the Guadalupe Mountains, Culberson County, Texas.

# # #

RESOURCE INVENTORY AND APPRAISAL (VEGETATIVE SURVEY AND ANALYSIS)
GUMO-N-0013

INVESTIGATORS: David K. Northington) Texas Tech University
Tony L. Burgess)

SUMMARY OF PROGRESS: The relatively small area and the many unique botanical features of the Guadalupe Mountains National Park necessitate a relatively thorough inventory for intelligent management and planning. Although the flora of the Guadalupes is fairly well known, specific habitats and locality data are scanty. To date we have collected over 1700 specimens from the park representing about 450 species of vascular plants. All collections have been located as precisely as possible and the habitat briefly described. The material collected has been used by mammalogists both for identification of species occurring at trap sites and for comparison with stomach contents of seed-eating rodents. The specimens will be available for study to any future investigators requiring botanical reference material from the park.

We have reviewed the works of Gehlbach, Robinson, and Potter and Warnock dealing with vegetation of the park. Our own observations generally confirm their interpretations; however the pattern of vegetation is complex, and many sites defy simple categorization. Our experience indicates that vegetation of the Guadalupe Mountains is best viewed as a continuum of species which respond individually to interacting environmental factors including elevation, exposure, and substrate composition. The various associations grade into one another in response to variation in physical and historical characteristics of the sites, the zone of transition being a direct function of the degree of change in the habitat. For example, a stream running at the base of a limestone cliff presents an abrupt change in habitat from the wet streamside to the drier crevices, and this discreteness is mirrored by the plant communities of the two sites. On the other hand, a continuous canyon bottom changing from 7500 ft to 5500 ft in evelation will show a gradual change in the composition of the riparian woodland, with species occurring according to their individual elevational tolerances.

Species of interest because of their scarcity or unusual distribution can be grouped into categories based on similar habitat requirements or distributional patterns. Some species could be included in more than one category; therefore the groups here recognized must be considered only as simplifications of trends observed in independently evolving entities. Usage of the terms "rare" and "endemic" varies greatly among botanists, and depending on the criteria applied, the number of rare or endemic species in the park can vary from 30 to over 100. The taxa mentioned below are considered exemplary but by no means constitute a total enumeration of unusual species found in the Guadalupe Mountains.

An interesting assemblage of species inhabits crevices of limestone cliffs and ledges in higher parts of the range. Most are known only from the Guadalupe Mountains and the Sierra Diablo to the south. Included among these small, rock-dwelling endemics are *Nama xylopodum*, *Polygala rimulicola*, *Silvia summa*, and *Hedeoma apiculatum*. These species often occur together on cliffs above 6500 ft elevation, but the most accessible populations are located on canyon walls of the McKittrick Canyon drainage.

Streambeds and seeps support riparian associations with unusual collections of species. *Aquilegia chaplinei* is restricted to the Guadalupe Mountains but most species in this category are widespread to the east or north and occur here as disjunct populations near the limits of their respective ranges. *Celastrus scandens*, *Asclepias tuberosa*, *Lactuca graminifolia*, *Lilium philadelphicum*, and *Quercus muhlenbergii* are examples of this group. The best-developed riparian communities are located in North and South McKittrick canyons.

The relict coniferous forest of the high parts of the mountains contains several species widespread in mountains to the north and west but known from nowhere else in Texas. Among these montane forms are *Fragaria bracteata*, *Physocarpus monogynus*, *Amelanchier utahensis*, and *Berberis repens*. Typical stands of forest occur in the Bowl, the north side of Bush Mountain, and higher parts of South McKittrick Canyon.

A few species associated with the Chihuahuan Desert or its margins occur in the Guadalupe Mountains as disjunct populations. *Yucca faxoniana*, *Sophora gypsophila*, and *Jatropha dioica* are at the northern limits of their ranges here. The occurrence of *Sophora* in Humphrey Canyon is especially puzzling since the only other location known for this species is a gypsum outcrop over 150 miles to the south in Mexico. An investigation is being conducted to determine the exact relationship between these two populations.

Included within the park on the west side of the mountains are gypsum outcrops supporting a flora restricted to this habitat. *Senecio warnockii*, *Mentzelia humilis*, and *Nama carnosum* are all gypsophiles of restricted distribution in the northeastern Chihuahuan Desert.

In addition to the floristic inventory, an investigation of vegetational dynamics is in progress. Several permanent plots have been established to permit vegetation monitoring over long periods. The method used divides a plot into 5-m grids within which a list of all species present a density count of woody species is made. Coverage estimates are provided by 20-m line intercepts run perpendicular to the long axis of the plot at 5-m intervals. Plot size is either 20 X 50 or 20 X 25 m, depending on the nature of the site. Most of the plots are located on the west side of the mountains, and represent examples of most vegetation types at lower elevations, including the *Jatropha dioica* colony. Among other sites monitored is the newly established camping area above Pine Spring Canyon, where three plots have been established to evaluate human impact on the area. We anticipate that data from existing and future plots will prove useful to studies of vegetation in the park.

The status of several species occurring in the Guadalupe Mountains is uncertain, and detailed systematic studies will be required to clarify relationships. One such study is currently underway to determine the extent of hybridization between species of *Agave* in McKittrick Canyon. The distinction between *Yucca faxoniana* and *Y. carnerosana*, which has been reported from the park, needs to be investigated. Other systematic problems of local importance are in the genera *Philadelphus*, *Senecio*, and *Coryphantha*, to name a few.

The richness and diversity of the flora of the Guadalupe Mountains are exceptional, and it is fortunate that efforts are being made to preserve this unique area. Our studies indicate that few of the species are currently threatened; however the marginal nature and small area of many communities implicates a delicate equilibrium of environmental factors. A relatively minor shift of a single factor could prove catastrophic for an entire association; therefore we urge caution and careful scrutiny in planning any development within the park.

# # #

METEOROLOGICAL STUDY

INVESTIGATORS: Eugene M. Wilkins)
J. D. Suggs) Advanced Technology Center, Inc.
Gary M. Ahlstrand, National Park Service

SUMMARY OF PROGRESS: Three weather stations have been installed along the proposed tram route. Wind speed and direction, temperature, relative humidity, and precipitation are recorded continuously for 31-day periods. The stations at 2620 m and 2400 m are solar powered, while the one at 1790 m is operated from storage batteries and also records shortwave (visible) radiation. Data are collected monthly, summarized, and sent to Wilkins and Suggs for analysis.

Synoptic weather records during and prior to high velocity winds in the study area are being investigated by Wilkins and Suggs to determine if these wind episodes can be predicted on the basis of precursor information appearing on the synoptic charts.

A preliminary report by Wilkins and Suggs, *Investigation of Selected Strong Wind Episodes at Guadalupe Pass* has been prepared.

# # #

QUATERNARY VERTEBRATE FAUNA OF CAVES 05, 08, AND 09, GUADALUPE MOUNTAINS NATIONAL PARK, TEXAS

INVESTIGATORS: Craig C. Black)
Lloyd E. Logan) Texas Tech University

SUMMARY OF PROGRESS: Nine of the originally proposed eleven trenches have been excavated, screened, lined with plastic, and refilled. These trenches are located in the following caves: C-05--six Trenches, C-08--two Trenches, and C-09--one Trench.

The concentrate derived from screening the dirt from these trenches has been taken to Texas Tech University where approximately 30% has been picked for organic remains. Several hundred plant macrofossils, over 3000 individual teeth, and several hundred jaws with two or more teeth have been recovered.

The following species, tentatively identified from the cave deposits, are not recorded from the park today: *Opheodrys vernalis* (smooth-scaled green snake), *Trimorphodon biscutatus* (Texas lyre snake), *Coragyps* cf. *occidentalis* (Pleistocene black vulture), *Sorex* cf. *cinereus* (masked shrew), *Cryptotis* cf. *parva* (least shrew), *Notiosorex crawfordi* (desert shrew), and *Marmota flaviventris* (yellow-bellied marmot).

Due to the very large volume of vertebrate material, work for the M.S. Thesis of Logan will be restricted to C-05 but work on the other caves will be carried out as planned. Due to a C-14 date of 13,060 ± 280 years YBP (A-1549) near the surface in C-09, and the first trench in this cave showing over 5 ft of deposits, Cave 09 is a definite possibility for learning much about the 10,000 to 20,000 years YBP fauna and environment of the area. One other trench is currently planned in C-09 and will be excavated in the near future. This cave should definitely be considered for an expanded excavation in the future should funds become available. All three caves contain abundant vertebrate material that will be very important in determining the prehistory of the area.

# # #

LOCATION AND INVENTORY OF CAVES

INVESTIGATOR: Charles M. Peterson
National Park Service

SUMMARY OF PROGRESS: I have continued to systematically examine backcountry areas of the park for caves. No new caves were located and the total known caves remained at 15. I have spent about 15% of my time on this ground reconnaissance.

I have arbitrarily set a 5-year time span for the ground reconnaissance and inventory of caves. During these years I will extensively cover the Guadalupe backcountry; however, one can be assured that new caves will continue to be found after this project terminates due to the extreme ruggedness of the park.

# # #

RESOURCE INVENTORY AND APPRAISAL (SMALL MAMMAL SURVEY AND ANALYSIS)

GUMO-N-0013

INVESTIGATORS: Robert J. Baker)
Hugh H. Genoways) Texas Tech University
Robert L. Packard)

SUMMARY OF PROGRESS: All major habitat types in Guadalupe Mountains National Park have been surveyed for the occurrence of mammals. Fifty-four species of mammals have been collected or observed within the park, and four additional species may occur within the park boundaries. A survey of the literature and museum collections reveals that nine species which occurred in the area in the historical past are no longer present. One of these speçies, Merriam's or Arizona elk, is extinct. Representatives of each species collected have been karyotyped, preserved, and cataloged into the mammal collection of The Museum, Texas Tech University. The following data have been recorded for each animal captured: locality, date, elevation, sex, genus, species, external reproduction condition, habitat notes, climatic factors, molt data, age, and general comments.

Areas surveyed during the past year included: West Dog Canyon, Bush Mountain, Blue Ridge, Mescalero, The Bowl, Pine Springs Canyon, McKittrick Canyon, Nipple Hill, Lost Peak Mine, Upper Dog Canyon, Lewis Well, Stage Coach Hills, Patterson Hills, Williams Ranch House, and numerous intermediate localities. Two park records were collected; the banner-tailed kangaroo rat and the piñon mouse.

Extensive ecological data have been gathered in conjunction with survey trapping. These data are being analyzed to determine the role of mammals in the local ecosystem. Food habits, population studies, and habitat analyses are being utilized to study the interrelationships of plants and mammals in the park. Specific investigations are in progress concerning the status of the Guadalupe Mountains vole, woodrat ecology, kangaroo rat ecology, small mammal population dynamics in Upper Dog Canyon, and distribution of deer mice in the park.

Investigations are in progress concerning the habitat requirements, parasites, predators and some physiological parameters of the vole. The genetic and zoogeographical relationships of the vole as compared to those of the same species in southwestern New Mexico is being studied. The determination of vole distribution within the park is near completion. The determination of the status of the Guadalupe Mountains vole is an important undertaking, because this rodent is listed as "status undetermined" on the endangered species list. The prime habitat of the Guadalupe Mountains vole is grassy meadows which are very attractive to park visitors as camp sites. Increased camping pressure could result in the destruction of much of the preferred vole habitat and result in the demise of this genetic entity.

The coexistence of Ord's kangaroo rat and Merriam's kangaroo rat is being investigated south and west of the Guadalupe Mountains. This area may be subjected to future road building and "improvements" which may alter the interractions between the two species of kangaroo rats as well as populations of the other desert species occurring in that area of the park. Increased human usage would inevitably accompany road improvements. By monitoring the kangaroo rat populations, the effect of increased human impact may be quantifiable. The distribution of kangaroo rats in the park has been determined and a study of their food habits as inferred from an analysis of cheek pouch and stomach contents is in progress.

The ecological distribution of woodrats is being investigated to determine the feasibility of using woodrats as a biological indicator of habitat conditions. Increases in woodrat numbers generally accompany overgrazing in areas where overgrazing favors an increase in numbers of cacti and other succulents. Three species of woodrats occur in the park. The Mexican woodrat and the white-throated woodrat are in contact around the perimeter of Upper Dog Canyon, and the white-throated woodrat and the south plains woodrat are in contact north of the Patterson Hills on the west side of the park. Environmental changes whether caused by human impact or climatic changes will probably cause shifts in these zones of contact. By monitoring the woodrat populations, changes in habitat conditions can be detected. The habitat around representative woodrat dens has been quantified by means of quadrats and transects to determine differences in ecological preferences and requirements between species. The materials used in den construction have also been quantified for statistical comparisons.

Six species of deer mice of the genus *Peromyscus* have been collected in the park. Prior to this survey only two species of deer mice had been reported from the park area. The six species are being studied by means of karyology and morphology. This information along with ecological data gathered with each specimen will yield insight on the distribution and interrelationships of these mice.

A 12 X 12 station population grid with 15 m between stations is being monitored in the needle-grass-juniper association in Upper Dog Canyon near Dog Canyon Ranger Station. Mark and recapture studies in progress at this site will supply baseline information on the population dynamics of small mammals. Future monitoring of this grid would yield valuable information concerning changes in the local ecosystem caused by climatic fluctuations or human impact. It is planned that more population grids be established in other areas of the park. Data gained from such grids would be an extremely valuable park management tool.

The roles of plants and mammals in the ecosystem are intimately intertwined. By correlating mammals with the plant communities in which they occur, changes in mammalian populations may be inferred from changes in the quality and size of the plant communities. Those species of mammals which are restricted to certain plant communities within the park, such as the Guadalupe Mountains vole, can be monitored effectively by remote sensing. The data gathered during the mammal survey are being combined with data from the survey of plants to utilize most efficiently remote sensing when it becomes available. It will be necessary to employ more conventional methods to monitor the status of mammals which range through several plant communities.

Although several excellent studies of mule deer have been completed in the Guadalupe Mountains, the introduced herd of Rock Mountain elk has not been studied nor has the relationship between the elk and mule deer in the park been investigated. Merriam's elk had been extirpated from Texas before 1900. Forty-four Rocky Mountain elk were introduced in 1928; recent estimates of the herd size vary from 150 to 300 elk. It is essential that the status of this elk herd be fully investigated. Knowledge of their food habits, age structure of the herds, reproductive success, herd movements, and water stress are virtually nonexistent. This is the mammal that park visitors ask about most, yet very little is known about its status. Semiannual helicopter censuses in the spring and fall would be useful in determining the population and age structure of the elk herds and would result in much information on the distribution and abundance of other big game animals in the park. Other large mammals such as the gray fox, coyote, black bear, mountain lion, and bobcat also merit further investigations.

The Merriam's elk, gray wolf, bison, white-tailed deer, pronghorn antelope, big horn sheep, prairie dog, and possibly the grizzly bear and pine squirrel occurred in the area now encompassed by the boundaries of Guadalupe Mountains National Park during historical times. They are no longer present. Sound management decisions will be required in an attempt to prevent several other mammals from disappearing from the area. An isolated population of eastern cottontails may still exist in The Bowl. Several cottontails have been observed during field investigations but positive identification has not been determined at this time. The ranges of the gray-footed chipmunk, the Texas antelope ground squirrel, the Guadalupe Mountains vole, and the Guadalupe Mountains pocket gopher are limited to the Guadalupe Mountains and vicinity. Zoogeographically, the Guadalupe Mountains are an island in the Chihuahuan Desert inhabited by plants and animals of Rocky Mountain affinities. If environmental conditions ever prevail which favor the encroachment of the desert upon this island, species such as the gray-footed chipmunk, elk, eastern cottontail, Guadalupe Mountains vole, and porcupine will be eliminated or at least extirpated from the area. With favorable conditions and sound management decisions it is hoped that this unique assemblage of mammals will be preserved for future generations.

CHECKLIST OF RECENT MAMMALS OF GUADALUPE MOUNTAINS NATIONAL PARK, TEXAS

P	*Notiosorex crawfordi*
C	*Myotis velifer*
C	*Myotis thysanodes*
U	*Myotis volans*
C	*Myotis californicus*
C	*Myotis leibii*
U	*Lasionycteris noctivagans*
C	*Pipistrellus hesperus*
C	*Eptesicus fuscus*
C	*Lasiurus cinereus*
P	*Euderma maculatum*
C	*Plecotus townsendii*
C	*Antrozous pallidus*
C	*Tadarida brasiliensis*
U	*Tadarida macrotis*
U	*Sylvilagus floridanus*
C	*Sylvilagus audubonii*
C	*Lepus californicus*
C	*Eutamias canipes*
C	*Ammospermophilus interpres*
P	*Spermophilus mexicanus*
U	*Spermophilus spilosoma*
C	*Spermophilus variegatus*
E	*Cynomys ludovicianus*
E	*Tamiasciurus hudsonicus*
U	*Thomomys Bottae*
U	*Pappogeomys castonops*
U	*Perognathus flavus*
C	*Perognathus penicillatus*
U	*Dipodomys ordii*
U	*Dipodomys spectabilis*
C	*Dipodomys merriami*
C	*Reithrodontomys megalotis*
C	*Peromyscus maniculatus*
U	*Peromyscus leucopus*
C	*Peromyscus boylii*
C	*Peromyscus pectoralis*
U	*Peromyscus truei*
C	*Peromyscus difficilis*
C	*Onychomys torridus*
C	*Sigmodon hispidus*
C	*Neotoma micropus*
C	*Neotoma albigula*
C	*Neotoma mexicana*
U	*Microtus mexicanus*
C	*Erethizon dorsatum*
C	*Canis latrans*
E	*Canis lupus*
P	*Vulpes macrotis*
C	*Urocyon cinereoargenteus*
U	*Ursus americanus*
E	*Ursus arctos*
U	*Bassariscus astutus*
C	*Procyon lotor*
P	*Mustela frenata*
U	*Taxidea taxus*
U	*Spilogale putorius*
C	*Mephitus mephitus*
C	*Conepatus mesoleucus*
U	*Felis concolor*
U	*Lynx rufus*
Ex	*Cervus merriami*
C	*Cervus canadensis*
C	*Odocoileus hemionus*
E	*Odocoileus virginianus*
E	*Antilocapra americana*
E	*Bison bison*
E	*Ovis canadensis*

LEGEND:

C	common
U	uncommon
R	rare
E	previously present, but no longer occurs
Ex	extinct
P	possibly occurs (within the known range)
I	introduced

# # #

SUMMARY OF WATERSHED AND LAND SYSTEM CLASSIFICATION STUDIES IN GUADALUPE MOUNTAINS NATIONAL PARK DURING 1974

INVESTIGATOR: Ernest B. Fish
Texas Tech University

SUMMARY OF PROGRESS: In connection with other basic biophysical and cultural inventory work being conducted by scientists from Texas Tech University on the Guadalupe Mountains National Park, an inventory of watershed characteristics and a land system classification were initiated in January 1974.

Delineation of the major drainage basins within the 77,500-acre park was accomplished using United States Geological Survey 15-minute quadrangles and National Aeronautic and Space Agency high altitude aerial imagery. This analysis resulted in the designation of 10 major watershed units lying partially or entirely within the park boundaries. The watershed units range in size from the 84 acres of a small headwater basin in the northeastern portion of the park to the large, 31,873-acre complex along the western portion of the park.

Determination of the hydrologic characteristics for each of the various watershed units is currently in progress; and these data will become a part of the basic resource inventory package. The watershed delineations also may provide a valuable stratification of the park in terms of evaluating management practices in terms of practice location vs area of impact. The implication of management programs initiated in the headwaters of a watershed unit must be considered in terms of their downstream impact. The drainage basin is a unique functional response unit for such evaluations.

The mapping of land systems at Guadalupe Mountains National Park is an attempt to differentiate the park into a number of subunits which are relatively more homogeneous within a unit than between units in terms of a number of ecological and environmental variables.

The approach utilized in this study generally follows the so called "landscape" technique developed by Austrailian scientists. This approach heavily relies upon aerial photographic imagery analyzed stereoscopically for units of similar tones, textures, and patterns. The approach rests upon the assumption that the image formed on the photograph is the best expression of the interaction of the biophysical and cultural variables present on a particular landscape unit. Following the delineation of major land systems within the park, the next emphasis in this study will be to define "land units" (the basic elements of a particular land system), and to determine quantitative values for a number of environmental and ecological factors in each unit. These data can then be utilized in data bank and computer mapping programs.

The park area was initially classified into nine tentative units utilizing Skylab satellite data. These units were later refined on high-altitude aerial photography resulting in 17 land system designations.

# # #

RESOURCE INVENTORY AND APPRAISAL (GEOLOGIC MAPPING AND SITE EVALUATION)

GUMO-N-0013

INVESTIGATORS: C. C. Reeves) Texas Tech University
James Goolsby)

SUMMARY OF PROGRESS: The geology of Guadalupe Mountains National Park is dominated by the famous Permian Reef complex. The present topography is largely due to deposition and reef growth which occurred during Permian time, some

300 million years ago. Formation of the reef was followed by deposition of younger marine and nonmarine materials that protected the reef complex from erosive forces for hundreds of millions of years. Uplift of the sediment-covered reef probably began in mid- to later Tertiary time and continued episodically until the late Pleistocene. Subsequent differential erosion (the reef and associated rock units being generally more resistant than later deposits) has sculptured the present landscape.

Possible geologic hazards along the proposed tramway route have been given priority. The tramway route extends from near the mouth of Pine Springs Canyon to a small bedrock bench just below the top of Guadalupe Peak, the highest point in Texas. The tramway will pass over at least five known faults; however, there is no evidence to indicate that any of the faults have been active since the Pleistocene. The faults should therefore not be considered as major deterents to construction of the tramway.

Jointing within the rock units throughout the entire area is prevalent and could be especially hazardous to any structure built near the edge of a vertical slope. Carrying capacity of a jointed material would increase with depth and therefore it may be necessary to extensively alter the ground surface where a tramway tower is to be placed. This may cause problems at the proposed location for the uppermost tower since altering the surface at this point would mar the natural beauty of the view from Guadalupe Peak. Joints cemented by massive calcite occur near Guadalupe Peak and should be treated as weak zones in the rock because of the tendency of calcite to cleave readily.

Thinly bedded units such as the Carlsbad Limestone, upon which the upper three towers will be located, may also present construction problems.

Cavities within the Carlsbad and Capitan limestones are possible hazards. No cavities were detected from surface studies; however, a geophysical survey of the immediate areas upon which tramway towers are to be constructed by portable reflection equipment is recommended.

Tram towers located near the bottom of Pine Springs Canyon at the base of steep slopes must be carefully placed to avoid rock-fall chutes. The danger of damage due to rock fall can be greatly reduced by locating the towers either away from these steep slopes or on low ridges (in this vicinity generally formed by resistant sandstone units within the Cherry Canyon Formation).

Planners of developments near Pine Springs Canyon should be aware that only the upper few feet of much of the alluvial and colluvial material is solidly cemented with $CaCO_3$. At greater depths (usually 5 to 15 ft) the alluvial-colluvial material is not cemented and is very permeable and porous. This type of situation has a negative effect upon the bearing capacity of the soil and may also create sewage disposal problems.

The greatest threat to construction on the west side of the park is the rapid erosion rate of the finer textured "younger Quaternary Alluvian." The areas covered by these materials should be avoided. Many faults cross the area, most of them trending parallel to the mountain front fault. These faults were active during Pleistocene time but do not appear to have been active in recent times. The faults do not represent a significant threat to construction; however, it is impossible to predict if and/or when a fault might become active. Interstate Highway 62 crosses many of these faults.

# # #

RESOURCE INVENTORY AND APPRAISAL (DATA ANALYSIS)

GUMO-N-0013

INVESTIGATOR: Benjamin S. Duran
Texas Tech University

SUMMARY OF PROGRESS: Introduction. One of the primary aims of the Guadalupe Mountains National Park (GMNP) study is to develop the computer software that can be used to monitor the park by means of remote sensing data such as that obtainable from the Earth Resources Technology Satellite (ERTS) or Skylab. This aspect of the study can be broken down into two main categories. First, the computer software should consist of a storage-retrieval computer package whereby all necessary and relevant information on the park is stored in computer accessible form. This category involves the definition, collection, and storage of all information relative to the study and includes both physical-cultural and biological resource data. Second, the software should contain the facility for taking new incoming information and comparing it with past information for the purposes of making decisions involving physical or ecological changes in the park. The first category consists of a storage-retrieval system which is associated with a data bank. The second category involves the capability of updating the data bank in the first category and together with it will result in a "dynamic" storage-retrieval information system.

Storage-Retrieval Computer System. To create a data bank for GMNP it is first necessary (and useful) to define a coordinate grid system.

Coordinate Grid System. GMNP consists of 77,500 acres. Our grid system consists of 100 X 100-m data squares (cells) so that GMNP consists of approximately 31,377 such squares. It is felt this size square is not so large as to make the description of the park excessively gross or so small as to make it impractical (or impossible) to obtain the necessary information on each square. It is to be expected that some portions of the park may have to be described in terms of smaller data cells. However, in studying the entire park a total description of the park is needed and concentration on particular areas can be decided on as the study progresses.

The ultimate aim in structuring a data bank is to describe each data cell as completely as possible. This description is in terms of physical-cultural and biological resources.

Physical-Cultural Resource Data. The physical-cultural resource data includes the following data on a cell by cell basis: location of data cell, historical site data, archaeological sites, camp sites, roads, and geology (soil type). These are just some of the data that are of interest. A more complete list has been compiled by N. Guse (preliminary draft 1973).

It may be desirable to study certain portions of the park in greater detail. For example, one may want to study the camp sites in the park for human impact. The same type of information system can be developed for camp site areas in which case the data cells should be smaller. However, the computer program which utilizes 100 X 100-m data cells can be easily modified so that it can operate on areas with smaller data cells.

A computer program that assumes data based on 100 X 100 m^2 data cells has been developed at Texas Tech University, although the makeup of the data file system has not been completely defined. However, sample runs involving some of the cultural resource data (historic and archaeological sites) have been obtained. The output of the program consists of a map of GMNP based on units of 200 m, that is, each vertical or horizontal space corresponds to 200 m. This choice is arbitrary and a simple modification of the program would lead to another desirable unit.

As an example, the program will scan the data cells which comprise GMNP, detect those which have a historic site, print the name, location, and code of each site, and finally print a map consisting of the boundaries of the park and historic sites according to the code. The data involving the historic sites is in card-form at present but, once the complete data bank is structured, the program will be accordingly modified.

As another use of the program, suppose that one desires to know the vegetative make-up of GMNP contained say between point A with coordinates 104°53'8" Longitude, 34°53'2" Latitude, and point B with coordinates 104°50'32" Longitude, 34°52'24" Latitude. Given the locations of A and B, the program will print a map consisting of the boundaries of GMNP together with the vegetative indicators of the rectangular area containing A and B as two vertices. The output also contains a description of the area in terms of a vegetative code. Since a vegetative map of GMNP has not yet been obtained the sample runs were obtained using artificial data. However, once the data bank is obtained the program will operate on real vegetative indicators.

The program under discussion can be expanded to operate on the data bank, on a cell by cell basis, retrieving any information requested by the user in terms of a map together with the pertinent indicators. The use of the program is thus limited by the ability to implement data into the data bank. A major problem for certain types of data is one of data acquisition. This is particularly true in the case of vegetative data where one must define the vegetation (or cover) of GMNP on a cell by cell basis. In fact, for the sake of long-range monitoring of the park it will be necessary to up-date the data bank periodically. This can be done only if one develops a computer package that utilizes data that can be obtained periodically and expeditiously, such as ERTS or Skylab data.

Biological Resource Data. In most cases it is significantly more difficult and time consuming to acquire biological resource data than cultural resource data. We have discussed a program that operates on biological resource data but such data is not yet available. We now discuss some computer software that is operating and available, and a procedure that will yield vegetative data. This procedure uses data of the type obtained from ERTS or Skylab. Consider GMNP (or any other region) as being made up of a large number of squares (not necessarily 100 X 100 m^2). The ERTS data for each square consists of four numbers corresponding to the light-energy radiated in four bands of the light spectrum. Thus, each square is represented by an array (x_1, x_2, x_3, x_4). The problem is one of classifying each array as belonging to one of, say, k classes, where k is the number of different types of vegetation (or other ground cover). This classification can be carried out by means of some well-known statistical classification and clustering procedures. There exist some programs that will perform this type of analysis. One such program is the Purdue University LARS (Laboratory for the Applications of Remote Sensing) program. This program consists of two parts. The first part has been implemented at Texas Tech University and can be used to categorize each square in a given region, given the ERTS data tape corresponding to that region. (A data tape may require preprocessing to make it compatible for the LARS program but this does not present a big problem.)

Thus, given a data tape of GMNP one can partition the park into k nonoverlapping and "homogeneous" regions. Then, by collaborating with the biological scientist who is familiar with the park, one can determine if the partitioning is reasonable. If it is, several regions whose composition is well-known can be selected for the purposes of extrapolating to the entire park. This procedure will lead to a vegetation map of the park and one can obtain a code whereby each data square will have a vegetative indicator. Consequently each data cell will have a label designating it as belonging to a given vegetative class and by means of the computer program discussed above, one can scan the data file and retrieve the vegetative indicators for all data cells in the form of a map including the appropriate code. Furthermore, if these ERTS (or Skylab) data tapes are obtained periodically then the data file can be updated accordingly and current information can be compared with past information for the purposes of detecting changes in the park.

Concluding Remarks. The basic information retrieval program has been developed, although it will need to be expanded gradually as the need arises. In order to construct a dynamic data bank the following items are recommended:

1. Coordinate and utilize the computer software that will yield a vegetation map of GMNP.

2. Develop the software that will transform the partitioning in (1) into a vegetation map in the desired coordinate system (e.g., 100 X 100-m grid system) and incorporate it into the data bank.

3. Develop the software for up-dating the data bank according to the results of (1) and (2) as current information becomes available.

Efforts to implement (1), (2), and (3) as a complete self-contained package are currently being made and the results thereof will be reported at a later date.

# # #

ECOLOGY OF FIRE, CARLSBAD CAVERNS AND GUADALUPE MOUNTAINS NATIONAL PARKS

INVESTIGATORS: Gary M. Ahlstrand) National Park Service
Michael R. Glass)

SUMMARY OF PROGRESS: Evidence suggests that fire has been a greater influence on the ecosystems of Carlsbad Caverns and Guadalupe Mountains National Parks in the past than generally has been recognized. Analysis of fairly recent burns in the area has shown that vegetation dynamics are altered on the site following fire but that seral species typically do not become established on the burn. Information concerning conditions prior to, during, and after burning are needed to adequately understand the responses of vegetation to fire, and future studies of this nature will be conducted on well-documented experimental burns designed to also test various fire prescription formulas.

Seed germination work has suggested reasons for the relative success of some species in the Chihuahuan Desert Region but more detailed investigations are required to determine the ecological amplitudes for seed germination in some critical species. Investigations of plant-water relations have been started and information from this phase of the research will give new insight into adaptive mechanisms of certain species. These investigations may also lead to a new method of predicting potential fire danger in the area. The final phase of the research will examine the degree to which burning affects microenvironment energy budgets.

When results from all phases of the fire research are considered together, the resource manager will have a tool that can be used in numerous ways to achieve different management goals. In addition, the results from this research should be applicable with only slight modification to other areas in the Chihuahuan Desert Region, such as Big Bend National Park.

# # #

HALEAKALA NATIONAL PARK

THE GEOLOGY OF HALEAKALA CRATER
HALE-N-0001

INVESTIGATOR: Gordon A. MacDonald
University of Hawaii

SUMMARY OF PROGRESS: The work is conducted on a part-time basis, as time and funds permit. Thus far, the mapping of the crater and west slope are essentially completed, on a scale of 1:12,000. Thin sections of approximately 100 rock samples have been studied, and study of additional ones is continuing. The final map of the crater is being assembled. The thin section work has been supplemented by four new chemical analyses. The new mapping is on a larger scale than that done in the 1930s and early 1940s, and in addition will show rock types as well as age, whereas the earlier mapping showed only age. Thus far the field work demonstrates that the plant cover is influenced far more by the general layer of surficial ash than by the type of underlying rock.

The field work is probably finished, unless unexpected gaps show up in the final compilation of the map. Progress on the latter has been slow during recent months because of lack of time. It will continue as rapidly as time permits.

# # #

PRESERVATION OF THE DARK-RUMPED PETREL

HALE-N-0006

INVESTIGATORS:

Dunatchik)
Kokubun)
Kuailani) Haleakala Park Staff
Kunioki)

SUMMARY OF PROGRESS: A yearly summer census of petrel burrows has been conducted by the Haleakala Park staff since it was begun by Larson in 1965. The census activities center around the west crater pali near the summit of Mount Haleakala and attempts to determine the number of active burrow nests, amount of predation, and a general index to petrel population size. Predator trapping near the burrows is done from March through October.

Only two rats were caught this year near the burrow area. It appears that predation was small again this year with only five burrows being raided. Eighteen new active burrows were discovered this year as compared to nine new burrows last year, however there were fewer active burrows this year (62%) compared to last year (76%).

Two dead petrels were found this spring just prior to the nesting season. Cause of death is unknown but it appeared (in both cases) to be from collisions with man-made objects.

It is recommended that the annual census of burrows be continued and perhaps, where possible, more thorough life history/population studies be made.

# # #

PLANT CHECKLIST & HERBARIUM

HALE-N-0009

INVESTIGATORS: Park Staff - Haleakala National Park District Rangers

SUMMARY OF PROGRESS: The project has been essentially inactive since its first major push in 1968 and 1969 when a number of specimens (mostly native) were collected and mounted. These are stored in the park's herbarium.

Additional work needs to be done to round out the collection, especially the exotic species from the Crater and Kipahulu districts. Once the field work is completed the checklist can be compiled.

This work will continue as time permits.

# # #

HAWAIIAN GOOSE "NENE PARK" PLAN

HALE-N-0010

INVESTIGATORS: Dunatchik)
Kokubun) Haleakala Park Staff
Kuailani)

SUMMARY OF PROGRESS: Two pair of nene continue to be housed in pens behind park headquarters. Both pair laid eggs this year, totaling 12. A clutch of three eggs was abandoned but renesting occurred. Nine eggs were incubated for the full period. Of these, six eggs hatched, three were infertile; of the six goslings, four survived and were released near park headquarters.

A total of nine goslings have been released near park headquarters over the last 2 years. They remained in the area a short time (month or two) and were not seen thereafter. The remains of one dead bird has been found. It takes 2 years for the nene to become sexually mature so it will not be until next fall that we can look for some of the birds to return to the area to nest.

The project should continue until the status of released birds can be determined.

# # #

THE VEGETATION RESPONSE TO FERAL MAMMALS AT KALAPAWILI RIDGE, HALEAKALA, MAUI

(PIG EXCLOSURE--KALAPAWILI RIDGE)

HALE-N-0011

INVESTIGATOR: James D. Jacobi
University of Hawaii

SUMMARY OF PROGRESS: The predominately native *Deschampsia* grassland of Kalapawili Ridge, Haleakala, represents the only large alpine grassland of this kind in Hawaii. The importance of maintaining this area in its natural state is multifold. It is an important part of the habitat of the nene and is currently under a propagation and establishment program by Haleakala National Park and the state of Hawaii; it contains the highest known apline bog in Hawaii; it represents a unique facet of the diverse Hawaiian natural ecosystem.

The area is currently frequented by feral pigs and goats, both with high populations in the rain forest and dry forest areas adjacent to this grassland. The Hawaiian ecosystem has evolved without the presence of these or any terrestrial mammals. Their recent introduction brought changes in the ecology of the natural areas, resulting in a significant disturbance and in some cases the loss of valuable native habitat.

It is not known how long feral mammals have been present in the Kalapawili area; it is known that feral pigs present significantly affect the natural dynamics of this ecosystem.

Through a clearer understanding of the roles which these exotic factors play in the dynamics of the Kalapawili grassland, sound management decisions must be made to regulate their influence.

A report of the work completed up to October 1974, with a preliminary analysis of data, was submitted to Haleakala National Park in November 1974. The important points are briefly summarized here.

The project deals with understanding the response of the Kalapawili grassland vegetation, particularly of native Hawaiian species, to the active presence of feral goats and feral pigs, both abundant in the area. The grassland vegetation was quantitatively characterized by means of three vegetation transects: 750 m, 1000 m, and 900 m long, respectively; on these species cover (abundance) was estimated in 2 X 2-m plots at 20-m intervals. Also noted was the amount of pig rooting in each of the plots. A total of 22.7% of the sampled area was found to have been rooted.

A fenced 10 X 40-m enclosure was constructed in the grassland in March 1974 to monitor the vegetation change following removal of the feral mammals. The vegetation is sampled with a point-sample technique along 10 transects running through the exclosure: 10 m inside the fenced portion and 10 m outside the fence. The outside portions of the transects will represent the present norm of the grassland under potential influence of feral mammals. The transects will be resampled every 6 months.

No significant changes in the vegetation have been noted to date other than what appears to be normal seasonal fluctuations in abundance. Vegetation response is often slow, particularly when the numbers of species are low (in this case 14 species). In view of the high percentage of rooting found throughout the grassland, it is expected that the exclusion of the feral mammals from the area will in time result in a marked difference in the vegetation dynamics. It is recommended therefore that the exclosure monitoring program be continued for a minimum of 5 years.

# # #

HAWAII VOLCANOES NATIONAL PARK

IMPACT ANALYSES OF EXOTIC MAMMALS UPON NATIVE HAWAIIAN ECOSYSTEMS
HAVO-N-4b

INVESTIGATOR: James K. Baker
National Park Service

OBJECTIVES: Nonnative mammals in Hawaii such as feral pigs and goats are scattered widely throughout the park. Research is underway on the life histories, numbers, distribution, and ecological impact of these animals that will give the National Park Service necessary data for formulation of management programs.

RESULTS AND DISCUSSION: Research has continued into the role of the pig in spreading mosquito populations through rain forest areas by the habits of making catchment basins in hollowed-out, tree-fern trunks and in making mud wallows. The distribution of such microaquatic habitats is confined almost entirely to the distribution of tree ferns since mud wallows are possible only in the same high rainfall areas of the forest necessary for the growth of tree ferns.

Collections have been made of organisms other than mosquito larvae inhabiting the catchment basins, and many taxa of several classes have been found. Analyses of mud taken from pigs and of mud scraped off on tree trunks by the actions of pigs rubbing themselves, shows resting egg stages of copepod and ostracod crustacea are spread from mud wallow to mud wallow.

Analyses of stomach contents taken from rain-forest/tree-fern habitats show that tree-fern parts, especially the interior starchy pulp, comprise approximately 85% of the diet; grasses and sedges comprise about 5%; ground litter and mud comprise about 5%; animal matter (grubs, caterpillars, and earthworms) comprise about 3%; and unidentified material about 2%. Even though animal matter is low in percentage it is found in nearly 50% of all stomachs examined. It appears that most of the time pigs spend in rooting is time spent searching for the above animal matter even though the results of their efforts comprise only about 3% of their diet. It appears that much of the destruction of ground cover vegetation, especially uprooting in grassy areas, is caused by a search for insect larvae and earthworms.

Follow-up studies continued in 1974 on the recovery of vegetation in a goat enclosure following removal of the goats (re: Impact analyses report, page 81, ONS Annual Report, CY1972). Observations showed much reinvasion of the denuded soils by exotic Jeruselem Cherry (*Solanum pseudo-capsicum*) and other nonnative plants. Native strawberry (*Fragaria vesca*) and *Peperomia* sp. recovered rapidly. Seedling, native mamani (*Sophora chrysophylla*) trees reappeared, probably from parent tree seed sources left standing in the enclosure following removal of the goats. Of the two very important native tree species completely eradicated by the goats, the pilo (*Coprosma rhynchocarpa*) and the mamaki (*Pipturus albidus*), only a single pilo seedling has so far reappeared.

The conclusions which can be drawn to date from the study are (1) ground cover species and small tree seedlings are removed first through browsing and/or trampling; (2) after ground cover is mostly eliminated sapling trees are bent over, broken down and the canopies eaten; (3) then the bark from soft-barked trees too large to break is peeled away and eaten, killing the trees; (4) the ground is pawed away to expose roots of trees left standing and root bark is eaten; and (5) the surviving trees are those species with bark too tough to peel away and eat. After goats are removed (6) ground cover species reappear relatively quickly; (7) seedlings from the tough-barked trees left standing reappear less quickly; and (8) seedlings of soft-barked trees are very slow to reappear, if at all, because all parent trees were eliminated.

# # #

REESTABLISHMENT OF THE NENE (HAWAIIAN GOOSE) IN HAWAII VOLCANOES

HAVO-N-22

INVESTIGATORS: James K. Baker)
Paul C. Banko) National Park Service
Donald W. Reeser)

OBJECTIVES: The native Hawaiian goose or nene, *Branta sandvicensis*, is an endangered species that is absent from lowland elevations of the park where it was once distributed. Destruction of native habitat by nonnative ungulates and introduction of predatory animals such as rats, mongooses, housecats, and dogs have been causes for extinction of lowland populations from sea level to about 4000 ft.

It is believed that habitats in lowland areas can be restored through feral animal control of predators, and that nene can be enticed to reoccupy former habitat by a program of penned, on-site breeding, and release of young in lowland regions.

RESULTS AND DISCUSSION: The pair of nene released into a pen built at 3000 ft elevation in August 1973 (re: Nene report, ONS Annual Report, CY 1973, page 154) did not nest in 1973, apparently because they did not reach sexual maturity by the winter nesting season. The birds did, however, go through certain courtship and nesting behavior preparatory to nesting but no nest was constructed.

In 1974 the pair began nesting in early December with construction of a nest beneath a fallen log. In the first week in January four young nene hatched out and a daily watch is being maintained to follow development and activities of the pair and young. If the young survive through the fledging stage they will be permitted to fly from the pen and it is theorized they will nest themselves 2 to 3 years from now in the same general area.

Another two nene pens were built in 1974; one in close proximity to the pen above at

3000 ft and the other approximately 8 miles away at an elevation of 4000 ft. A total of 15 new 1-year-old nene were obtained from the USF&W Patuxent Wildlife Research Center, Maryland, and the Northern Prairie Wildlife Research Center, North Dakota, for these pens. Three pairs were released in the lower pen and four pairs plus one male were released in the upper pen. All birds were weighed and color banded for individual recognition. These birds should form pair bonds and nest in 1976.

Inventories of plants were made in all nene pens, and predator control programs have been initiated around each pen.

# # #

THE BIOLOGY OF THE ENDEMIC PLANT SPECIES *HIBISCADELPHUS GIFARDIANUS* ROCK IN HAWAII VOLCANOES

INVESTIGATOR: James K. Baker
National Park Service

OBJECTIVES: The hibiscus-like species, *Hibiscadelphus giffardianus* Rock (family Malvaceae) is one of several plant species endemic to Hawaii Volcanoes. It was discovered in 1911 from a single known tree. The one tree died in 1940 but not before cuttings were obtained which eventually resulted in survival of eight trees now growing in Kipuka Puaulu, the type locality within Hawaii Volcanoes.

The species grows as a small shade-tolerant tree to about 30 ft in height under canopies of taller native species. Its decline to the single tree before discovery was due, most likely, to the bark-stripping habit of nonnative cattle, goats, and pigs which have abounded in Hawaii for nearly 200 years. Many succulent, soft-barked native species are extinct or have been threatened with extinction due to this feeding habit of ungulates.

The species also blooms with a long, curved, tubular corolla which is atypical of the open corollas of other hibiscus or hibiscus-related species. This phenomenon is believed to be an evolutionary adaptation in coevolution with the long, curve-billed Hawaiian honeycreepers, some of which are now extinct and which fed largely on nectar.

The tree species *Hibiscadelphus giffardianus* is, therefore, of value from three points of interest to the National Park Service at Hawaii Volcanoes: (1) it is an exceedingly rare endemic which helps document the evolutionary history of species formation in the park; (2) it helps document the role of extinction to native plants caused by the impact of nonnative animals in Hawaii and the park; and (3) it is a species that was probably of major importance to honeycreeper birds in support of a theory that loss of food supplies was one of several major causes for the decline and/or extinction of these rare, native birds.

RESULTS AND DISCUSSION: Studies reported upon in Annual Report, CY 1973, have continued in analyses of phenology of parent *Hibiscadelphus giffardianus* and *Hibiscadelphus hualalaiensis* Rock and F1 and F2 hybrids. The blooming period has been determined to occur in all months of the year although the peak occurs between March and October. Observations continued on nectar quality (sugar and amino acid content) and quantity and use of the nectar by honeycreepers, other birds, insects and rats. On some of the trees, rats have been very destructive in peeling away bark and biting through the bases of the flower calyx apparently to drink the nectar and obtain moisture from the succulent bark.

# # #

HORSESHOE BEND NATIONAL PARK

PLANT AND ANIMAL RESOURCES BASIC INVENTORY

INVESTIGATORS:
John D. Freeman)
Hugh D. Hamlin)
T. Anita Hutto) Auburn University
James W. Petranka)
John Robin Russell)

SUMMARY OF PROGRESS: The final report for this project has been submitted. New ranges for several species were established and rather diverse flora and fauna were observed and documented. Various communities were observed and successional development was indicated for each community.

This contract is complete, but it is the researchers' feelings that an extension of collection and observation should be carried over for at least a 1-year period to completely represent plant and animal life of the park area.

# # #

HOT SPRINGS NATIONAL PARK

AQUATIC RESOURCES OF GULPHA GORGE CREEK HOT SPRINGS NATIONAL PARK, ARKANSAS

INVESTIGATOR:
M. S. Ogra
Southern University, New Orleans

SUMMARY OF PROGRESS: The uppermost reaches of Gulpha Gorge Creek watershed which lie within and adjacent to Hot Springs National Park are the only remaining underdeveloped portions of this watershed. The present study is directed toward planning for the conservation and proper development of water with related land resources of the watershed.

OBJECTIVES: 1. To collect basic data on chemical, physical, and biological water quality in Gulpha Gorge Creek, Hot Springs National Park, Arkansas.

2. Formulate reaction procedures in the event that toxic substances are detected in the creek.

3. Formulate and improve methods and procedures to identify and measure the effects of pollutants on water uses.

4. To establish a baseline for water quality in the event that (a) part or parts of the watershed are used for recreational purposes, (b) new urbanization accompanied by increasing population, and (c) erosion resulting from land exploitation activities.

In order to achieve these objectives, the following categories of pollutants are being monitored: toxicity, salinity, acidity, turbidity, deoxygenation, and contamination. Seven sampling stations have been established keeping in view the environmental factors which can affect the water quality at those points.

STATION #1 Located south of Camp Ground: Extent of usage of camping facility may have some influence on downstream water quality.

STATION #2	Located north of Camp Ground.
STATION #3	Upstream near bridge on Hwy. 70, short distance before creek enters large lake.
STATION #4	Located at downstream side of low-water bridge above upper lake in Sleepy Valley: Possible effect of quarry will be determined.
STATION #5	Southwest of bridge 147 on Hwy. 70, a comparatively fast-current section; short distance from the confluence of the central and left branches of the watershed.
STATION #6	Located on Stonebridge Road, south side and below the dam at the foot of the large lake.
STATION #7	Located on old road off Hwy. 70, a short distance from Spring House. Spring House has been a center for commercial bottled-water supply.

# # #

INDIANA DUNES NATIONAL LAKESHORE

BASIC ECOSYSTEM SURVEY OF INDIANA DUNES NATIONAL LAKESHORE

INDU-N-0005

INVESTIGATORS: M. Reshkin)
H. Feldman)
C. Krekekr (?)) Indiana University
W. Keifer)

SUMMARY OF PROGRESS: Field work is complete on ecology, land use, and noise. Field work is 50% complete on geology. Laboratory work is 75% complete on land use and ecology, 50% complete on noise, and 50% complete on geology. Noise levels are higher than previously thought in all portions of the lakeshore. Biota mapping is useful in day-to-day environmental management, as, for example, the Cowles Bog preservation in light of potential dewatering and water chemistry changes.

# # #

INSECTS

INDU-N-0001

INVESTIGATOR: Verne Reaves
Field Museum of Natural History

SUMMARY OF PROGRESS: For the past several years I have been granted a collecting permit from the National Park Service, Indiana Dunes National Lakeshore. I have made an average of about five 1-day field trips into the dunes each summer collecting insects.

My own special area of interest is wasps (Hymenoptera), particularly parasitic wasps of the families Ichneumonidae and Chalcididae. I also have done some general collecting on my trips into the dunes, particularly of beetles (Coleoptera) and flies (Diptera). Several of my colleagues at Field Museum have special areas of interest as well, and I have been able to collect specimens in the dunes for them: hister beetles (Histeridae) for Rupert Wenzel; featherwing beetles (Ptiliidae) for Henry Dybas; phalacrid beetles (Phalacridae) for Michael Prokop; and various types of mites (Acarina) for John Kethley.

All specimens collected have been deposited in the insect collection of Field Museum, one of the five largest insect collections in the country. These specimens have proved useful in the research of the individuals mentioned above, and many have been loaned to researchers at other institutions. The specimens are of particular use in the taxonomic work which is the primary function of the Museum, i.e., the identification, classification, and representation of the various types of insects found in the world, particularly in the Midwest. Obviously, it is by such collecting, both general and particular, in areas such as the dunes, that collections like the one at Field Museum are developed and expanded. I hope to be able to continue this work in the dunes for at least the next several summers.

# # #

INDIANA DUNES NATIONAL LAKESHORE CHRISTMAS BIRD COUNTS

INDU-N-0002

INVESTIGATORS: Robert C. Tweit)
Mrs. M. David Shaeffer) Chicago Audubon Society
other volunteers)

SUMMARY OF PROGRESS: Three successive counts have been held (1972, 1973, and 1974) to census the winter bird population in a 15-mile-diameter circle centered SE of lakeshore headquarters. We plan to annually continue to monitor changes in winter bird populations as the land within the lakeshore reverts to a nature state, while the surrounding area is converted from farmland to residential.

We have acquired sufficient knowledge of winter bird populations to make better abundance estimates for the lakeshore bird list.

This year we plan to supplement the winter census with another during the breeding season (June 1975).

Each years census results are published in *American Birds*.

# # #

INDIANA DUNES NATIONAL LAKESHORE MONITORING PROGRAM

INDU-N-0006

INVESTIGATORS: Army Corps of Engineers
Chicago District

SUMMARY OF PROGRESS: The monitoring program is a 5-year (1973-78), cooperative effort between the National Park Service and the Army Corps of Engineers to (1) document and evaluate the Indiana Dunes National Lakeshore Protection Plan and (2) provide a data bank for purposes of planning and/or decision-making concerning future actions to achieve shore stabilization for the area. The work to be accomplished under the program consists of hydrographic and topographic surveys, aerial photography, littoral transport studies, analyses, and preparation of reports.

Progress during 1974:

1. A Littoral Environment Observation (LEO) program was established at two sites along the shoreline in April.

2. Hydrographic and topographic surveys at 21 ranges along the beach erosion project were made in June and December.

3. Sand samples were taken at selected locations at 13 ranges in conjunction with the above surveys (item 2).

4. Topographic surveys of the sand fill without lake soundings at six established ranges in the Mount Baldy area were repeated nine times.

5. Aerial photographs of the shoreline were taken in June and November.

6. Two wave-measurement gages were installed offshore of the study area in October.

A progress report of the first year activities will be available by February 1975. The scope of work dated 18 November 1974, program which was furnished to the Superintendent on 22 November 1974, is the proposed course of action for the monitoring program.

# # #

WATER-QUALITY MONITORING OF THE INDIANA DUNES NATIONAL LAKESHORE

INDU-N-0007

INVESTIGATOR: Leslie D. Arihood
U. S. Geological Survey

SUMMARY OF PROGRESS: One-half year of sampling has been completed. An excessive amount of manganese (8.5 m/1) was found at a road culvert in the Cowles Bog area,

# # #

EARLY WARNING AND EVALUATION OF EFFECTS ON NPS PROPERTY OF PROPOSED DEWATERING AT NIPSCO'S BAILLY #1 CONSTRUCTION SITE

INDU-N-0008

INVESTIGATOR: James R. Marie
U. S. Geological Survey

SUMMARY OF PROGRESS: On 2 October 1974, two observation wells and two staff gages were installed at the site. Continuous water-level data are being collected from one well. The other well will be equipped with a continuous recorder in advance of dewatering operations at the generator site. Twice-weekly (or more often) readings of the staff gages are being taken by NPS personnel. A digital model has been programmed for the area that will allow evaluation of effects on the inter-dunal ponds caused by dewatering on adjoining NIPSCO property. Currently, plans are to install three to five additional observation wells, make depth profiles of the ponds, and collect samples of the bottom material in the ponds during January 1975. These additional data are needed to complete and verify the digital model. There are no significant findings to report at present, because work completed so far only provides an "early-warning" system to alert NPS as to the effects of the proposed dewatering by NIPSCO.

# # #

FURNESSVILLE ROAD BREEDING BIRD CENSUS

INDU-N-0003

INVESTIGATORS: Robert C. Tweit
Emma B. Pitcher
10 other Chicago Audubon Society volunteers

SUMMARY OF PROGRESS: Mrs. Pitcher has conducted two successive breeding bird censuses in the burn area along Furnessville Road in order to follow changes in the bird population and plant habitat as the area slowly returns toward climax vegetation. Observation is being supplemented by netting and banding to follow return of individuals from one year to the next.

In 1974, 17 species bred in the 55-acre study area.

We plan to continue the censuses annually. The results will be published in *American Birds*.

# # #

A WATER-QUALITY ASSESSMENT OF THE INDIANA DUNES NATIONAL LAKESHORE

INDU-N-0004

INVESTIGATOR: Leslie D. Arihood
U. S. Geological Survey

SUMMARY OF PROGRESS: Collection of data, writing of the report, and some review of the report have been completed.

Usually, normal water quality existed within the National Lakeshore waters; however, there were some exceptions:

1. Highly mineralized water was observed at a West Beach interdunal pond and at a Bethlehem Steel culvert outlet.
2. Consistently higher temperatures were found in the culvert water.
3. Excessive chloride concentrations were found in wells near Ogden Dunes, Indiana, and in Pinhook Bog, particularly at the south side.
4. An interdunal pond near the Northern Indiana Public Service Company exhibited similar chemical quality to that in a nearby fly-ash settling pond owned by the power company.
5. A NIKE missile base discharged sewage high in fecal coliform bacteria and nutrient concentrations.
6. Pesticide concentrations were significant at Long Lake, Pinhook Bog at the northeast inlet, Little Calumet River, Markowitz ditch, and Kintzele ditch.

# # #

ISLE ROYALE NATIONAL PARK

ANALYSIS OF THE ISLE ROYALE ECOSYSTEM

INVESTIGATORS: Peter A. Jordan)
Daniel B. Botkin) Yale School of Forestry and
Gary E. Belovsky) University of Minnesota

SUMMARY OF PROGRESS: For a more detailed report, see "Progress Report 1973-74: Isle Royale Ecosystem Analysis" submitted to the National Park Service in October 1974.

During the period 1 July 1973 to 30 June 1974 our group continued the ecosystem analysis of the substrate-vegetation-moose-wolf ecosystem at Isle Royale National Park. The objective of the overall project, started in summer 1971, has been measurement of mineral and energy flux within an isolated, undisturbed mixed northern-hardwood and boreal-forest biome. Our interest also focuses on the ecological roles and adaptations of species for participating in the exchange of materials and energy. Field activities during 1974 included, (a) continued measurement of summer browse consumption by moose in the intensive study sites near Washington Harbor, (b) measurement of summer use of herbaceous plants by moose and hares, (c) establishment of a scheme to measure winter twigs removed by moose and hares, (d) measurement of browse intake and defecation rates during winter, (e) measurement of the production of aquatic plants and their utilization by moose, beaver, and muskrats, and (f) monitoring of daily activity cycle and home range in radio-tagged moose. In the lab we analyzed plants, moose tissues, soils, and water samples in our continuing program to describe the dynamics of N, P, K, Mg, and Ca while applying special emphasis to sodium dynamics.

Concentrations of N, P, K, Ca, Mg, and Na were determined for 233 specimens representing 23 specific or generic entities collected in August 1972 during a stratified-random sampling of browse production throughout the uplands of Isle Royale. Nitrogen, phosphorus, and magnesium were generally lower than found in samples we collected during August 1971 from three intensive study areas at the western end of the island. Phosphorus and calcium levels for given species differed between the years but not in a consistent manner. Sodium values for 1972 were notably higher in *Sorbus* and *Populus* than for 1971, while in the other species they were closely similar: we have no explanation for this.

In order to compare mineral concentrations in early season growth with those of late summer, we analyzed 259 specimens representing 28 specific or generic entities collected systematically at our three intensive study areas and at two other sites near Washington Harbor. These show nitrogen values in early June to be some 1.5-2 times higher than in mid-August regardless of site or year; similarly, phosphorus levels were 2-3 times greater in June than August. Potassium and magnesium showed no notable seasonal changes, and calcium in some species was notably lower early in the season. Sodium values appeared consistently lower in June, suggesting this mineral, and possibly calcium, accumulates in leaves as the season progresses.

Several other studies were carried out during this period. Competition during summer between hare and moose was examined by counts on the same plots of herbaceous stems cut by the respective species. Similarly, winter competition among moose, hare, and beaver was examined. These studies, designed and carried out by Belovsky, reveal that in summer hares prefer the forb *Streptopus roseaus*, twisted rosy stalk: if this is taken by moose in areas suitable for hare, i.e., near cover, then moose are a serious competitor for the hare. Also it was surmised that hare-cut seedlings of *Sorbus*, *Betula*, *Acer*, *Abies*, and other woody plants would, if allowed to grow, have later provided moose with desired browse. By influencing future composition of the shrub layer, hares act directly upon carrying capacity for moose.

We studied winter browsing by moose and discovered we can easily track an animal and record each twig it removes along the way. With some luck we were able to follow tracks made during a known period in which browsing rate, when twigs are converted to biomass, can be measured as can urination and defecation rates.

Additional studies of sodium dynamics included collecting urine of moose in both winter and spring by somewhat indirect methods. If these methods are even partially successful, they will add valuable information on how efficient moose are in conserving sodium.

Work continues on several simulation projects. Botkin and a colleague from IBM Research, Richard Levitan, are constructing a moose-browse model following a modification of Botkin's well-known forest-growth simulator, "Jabowa." Jordan and Belovsky have started on a simulation of moose population performance under different temporal patterns of mortality, namely the difference imposed by hunting instead of predation. The critical aspect of this model is the presumed affect on the future productivity of woody plants due to differences in seasonality of browse removal.

During summer 1974 we attempted to monitor individual moose for continuous time periods in order to account for how they expended time and energy. Five animals were equipped with radio transmitters, having been immobilized by the capture-gun technique. Of these, only two remained sufficiently close to our study area for monitoring to be practical. From tracking one of these, a cow with two calves, we accumulated a large amount of data useful to our analysis and reconstruction of time-energy budgets in moose.

# # #

INVESTIGATION OF PLANT SUCCESSION FOLLOWING FIRE
ISRO-N-2

INVESTIGATOR:	Ivan R. Tolley National Park Service
SUMMARY OF PROGRESS:	Photos were taken in 1963 and 1974 and will be taken again in 1983 for comparison purposes. Photos are available to other researchers.

# # #

ECOLOGICAL WILDLIFE STUDY
ISRO-N-1

INVESTIGATORS: Durward L. Allen) Purdue University
Rolf O. Peterson)

SUMMARY OF PROGRESS: In 1974 the Isle Royale wolf population reached an all-time mid-winter high of 31, with the 2 large packs numbering 16 and 12 wolves. The island has now been divided into two-pack territories for three consecutive winters. During each successive year, however, the amount of spatial overlap between the packs has increased, amounting to 15% of the island in 1974. One wolf was killed during a confrontation between elements of both packs. Accompanying the increased overlap of the two packs has been a decline in the calculated winter food availability on a per-wolf basis.

Frequent light snow through mid-February kept snow depths between 23 and 30 inches in open areas. An aerial moose census yielded an estimate (± 95% confidence interval) of 875 ± 260, approximately the same as in 1972. Adding a correction figure of 20% produced an estimate of about 1000 moose. After several years of heavy predation on vulnerable young moose, wolf predation resumed its former pattern in 1974, with heaviest losses among the oldest age classes. We infer that vulnerable moose within the young age classes have been gradually eliminated over a period of several years, following several winters of apparent nutritional stress. Spring emergence of green vegetation was late in 1974, and we found carcasses of seven moose that appeared to have died of malnutrition, one of these succumbing in mid-May.

Early summer field work concentrated on collections from wolf-killed moose from the previous winter, while wolf-related work was emphasized in July and August. Litters of pups were born in both packs, with a minimum of five established for the East Pack in August. The East Pack was unusually mobile, with specific activity areas occupied for only short periods, in contrast to the pattern followed by this pack in 1973 and the West Pack in 1974, which used a specific rendezvous site from mid-August through October. An aerial moose survey in October 1974, revealed a moderately low percentage of calves (15%) and continued high survival in the 1973 cohort, which was unusually large. Yearlings were estimated to comprise about 15% of the population.

# # #

INTERACTIONS OF MOOSE, WHITE SPRUCE AND BALSAM FIR

INVESTIGATORS:
Joan Edwards)
Gerald R. Molhman) University of Michigan
Lucinda Thomson)

SUMMARY OF PROGRESS: During the 1974 field season (15 May - 3 October), we (1) observed moose and (2) began plant-marking studies on the northeastern portion of Isle Royale. From the moose observation studies, we obtained a preliminary list of moose foods and compiled initial data on seasonal changes in the moose diet. We are presently attempting to correlate changes in the moose diet with the known information on physical and chemical changes in the plants. We also observed several instances of young calves "learning" to feed by following their mother (manuscript being submitted for publication). The data on the plant-marking studies are presently being analyzed. These studies involved marking plants (both eaten and uneaten) in three different study sites: the main island (southwest of the Merritt Lane campsite), Porter's Island (SW end), and Edwards Island (SW end). These plants will be observed for three field seasons to (1) determine the herbivore stress on the plants and (2) determine the effect of moose herbivority on the reproductive success of these plants. Next summer, we would like to expand this portion of the research to include (1) a study site on Passage Island and (2) clipping studies. The latter will provide knowledge as to the amount of foliage removed. (Note: this addition will be cleared with the NPS before it is initiated).

We definitely feel that this first field season was successful. Edwards' doctoral committee is pleased with her work. She has attained candidacy which should enable her I.E.Q. fellowship to be continued for another year.

# # #

AN ECOLOGICAL STUDY OF LEECHES OF ISLE ROYALE NATIONAL PARK
ISRO-N-I

INVESTIGATOR: Martin W. Grosnick
Northern Michigan University

SUMMARY OF PROGRESS: All field work has been completed; work on the thesis portion is progressing slowly.

# # #

DEMOGRAPHIC PARAMETERS OF ISLE ROYALE SMALL MAMMALS
ISRO-N-I

INVESTIGATOR: Wendel J. Johnson
University of Wisconsin Center--Marinette

SUMMARY OF PROGRESS: In June 1974, a paper was presented at the 54th Annual Meeting of the American Society of Mammalogists at Binghamton, New York. The report was entitled *Demographic Parameters of the Isle Royale Red Squirrel.* In September another paper was presented at the 11th Annual Lake Superior Biological Conference held at Northern Michigan University. This paper was entitled *The Isle Royale Deermouse.*

No field work was performed during 1974. It is my intention to make at lease one field trip to the island during 1975. I would like to observe present red squirrel and deermouse populations and contrast them to my earlier findings.

# # #

ECOLOGY OF SPRUCE FIR FORESTS
ISRO-N-I

INVESTIGATOR: Robert A. Janke
Michigan Technological University

SUMMARY OF PROGRESS: During the period 1 January - 21 May 1974 most of the data associated with field work in the summer of 1973 were processed. James de Waal Malefyte completed a Master's Thesis which summarized findings on the study of interrelationships among red squirrel, snowshoe hare, and moose populations and the various post-fire successional stages of the boreal forest type. Significant findings were: (a) red squirrel abundance in forest stands are correlated with the basal area of conifers of cone-bearing age; (b) among conifers, white spruce is of primary importance to red squirrels; fir and black spruce of lesser importance; (c) because of the above findings and because conifers tend to increase in numbers and in cone-bearing capacity as a forest stand matures, squirrel numbers should increase as a forest stand ages; (d) moose numbers, as determined by winter pellet groups, increase with forest stand age for stands older than about 35 years; (e) moose numbers are correlated with the amount of fir browse present. This probably explains why moose are more numerous in the older forests, since fir tends to increase with stand age. The birch and aspen browse, once so prevalent in the 1936 burn, are now beyond moose reach, so that moose now must depend mostly on fir.

(f) Snowshoe hares are most abundant in stands where moose are absent and are absent in stands where moose are most abundant. (g) Moose browsing seems to favor squirrel populations by reducing competition of fir with white spruce. Where spruce is not present, moose may produce the opposite effect on squirrels.

Sandra de Waal Malefyte completed her Master's Thesis in June on the ecology of thimbleberry (*Rubus parviflora*). Her most significant findings were: (a) Thimbleberry abundance is strongly correlated with the amount of birch and aspen in the tree canopy, particularly aspen. This suggests that thimbleberry may be a fire-related species. (b) Thimbleberry is more prevalent in northfacing slopes than southfacing and more prevalent on the lower portions of a slope than on upper portions. This suggests a preference for a moist site. It is rarely found on water-saturated soils, however. (d) No relationship was found between thimbleberry cover and tree seedling establishment.

Graduate student Randall Raymond, using the original land survey notes of William Ives (1847), constructed a map of areas recently burned at that time. The total recently burned acreage than was relatively small and was mostly located in the Rock Harbor area where mining activities were just beginning.

Raymond, Ronald Kapp, and I submitted a paper for publication on the geologic significance of sediment cores taken from 12 different inland lakes and bays. The lakes were categorized with respect to their relationship to postglacial Lakes Minong and Nipissing; (a) those never submerged by the high-water levels of either Minong or Nipissing, (b) those covered by Minong waters but not Nipissing, and (c) those inland lakes covered by both Lakes Minong and Nipissing. All cores begin in reddish-brown silty clay, which places the origin of all of the lake basin deposits at Valders age. The major stratigraphic feature of several of the cores is the homogeneous gray clay which overlies the reddish-brown clay in several of the basins. This gray clay is indicative of the incursion of high waters into these basins during the Lake Minong-Nipissing interval. Comparisons of the sediment sequences with the maps showing the shoreline of Isle Royale at Minong and Nipissing time aid in separating those basins affected by only Lake Minong from those affected by both Lakes Minong and Nipissing. There is an indication that the low water lake stage, Lake Houghton, may have had some effect on at least two of the basins sampled.

Soil profiles of three more study sites, examined during the summer of 1973, were described in a report by Steven Shetron, submitted to NPS. This, added to those from 1972, makes a total of 19 study sites in which soil profiles have been described in detail, named, and classified according to the Comprehensive System of Soil Classification of the National Soil Survey.

During the summer field season of 1974, Raymond completed tree sampling along section lines for comparison with Ives' survey notes of 1847. With the assistance of Ronald Kapp, several more sediment cores were taken from inland lakes to obtain sufficient material for pollen analysis, charcoal analysis, and radiocarbon dates.

# # #

ISLE ROYALE VISITOR STUDY
ISRO-N-2621

INVESTIGATOR:	Robert C. Stinson Michigan Technological University
SUMMARY OF PROGRESS:	Progress was minimal during the 1974 park season due to illness in the research team.

Data collected in 1974 is insufficient for the establishment of the significance of any findings. Preliminary work indicates many campers are inadequately prepared in terms of physical condition, equipment, and time budget. Preliminary data on wilderness perception by visitors indicates data will be of significant value to park management when data collection and analysis is completed.

Project should be continued and pursued to completion during the next park season.

# # #

AN ECOLOGICAL STUDY OF THE AMPHIBIANS AND REPTILES OF ISLE ROYALE

INVESTIGATOR: Don Moll
Illinois State University, Normal

SUMMARY OF PROGRESS: Ten of twelve of the recorded species of amphibians and reptiles of Isle Royale have been observed or collected and their ecological requirements studied. *Rana sylvatica* and *Necturus maculosus* have not been observed yet. One specimen of the species collected has been prepared for deposition in the IRNP museum.

Although much interesting data have been accumulated, I believe any statement of significant conclusions should await further collection of substantiating facts.

Research will continue as planned. The length of the research program will depend on the amount of financial support I receive, as this factor directly controls the amount of time I am able to spend on the island each year.

# # #

JOHN D. ROCKEFELLER, JR. MEMORIAL PARKWAY

VEGETATION OF THE JOHN D. ROCKEFELLER, JR. MEMORIAL PARKWAY

INVESTIGATOR: A. A. Beetle

OBJECTIVE: To describe the vegetation of the John D. Rockefeller, Jr. Memorial Parkway.

SUMMARY OF PROGRESS: During the summer of 1973, a study was made of the distribution of vegetation types in the John D. Rockefeller, Jr. Memorial Parkway, an area situated between Grand Teton and Yellowstone national parks. Notes were taken on the variety and frequency of the understory vegetation, ecological stability, and the degrees of constancy in association with physical factors of the environment. It is hoped that the following outline will be helpful in interpretation of the visible landscape.

The vegetation of the parkway has been divided into 14 types based on the dominance of different species. In the case of lodgepole pine the type is further divided into six subtypes because of its overwhelming importance in terms of area covered. The majority of the species encountered in the parkway (i.e., species diversity) are associated with other vegetation types than lodgepole pine. The most unusual species are associated with lodgepole pine (especially *Xerophyllum tanax*) and hot springs (especially *Panicum thermale*). None of these seems to be especially threatened under the present management although some individual species deserve further attention to determine whether they are naturally rare or also endangered.

The vegetation types have been named as follows:

1. lodgepole pine
2. limber pine
3. weeds indicating human occupation
4. willow bars and bottoms
5. narrowleaf cottonwood
6. willow/sedge meadows
7. grass meadows
8. bogs or dead lakes
9. quaking bogs and hot springs
10. mountain/big sagebrush
11. low sagebrush
12. quaking aspen
13. douglas fir
14. dry parks

# # #

JOSHUA TREE NATIONAL MONUMENT

ECOLOGY OF DESERT BIGHORN SHEEP IN JOSHUA TREE NATIONAL MONUMENT

INVESTIGATOR: Charles L. Douglas
University of Nevada

SUMMARY OF PROGRESS: Aerial surveys by fixed-wing aircraft and helicopter were conducted to determine locations of bighorn sheep and suitable habitat for this species. Numerous ground surveys were conducted to become more familiar with the monument and its vegetation.

In cooperation with monument personnel, various springs and artificial watering sources were inspected, and new watering sources were searched for, both on the ground and from the air. Two, and possibly three, new sources have been located.

Time-lapse movie cameras were placed on springs and guzzlers in May 1974 as a trial endeavor. Results from these counts were encouraging. Age structure of the animals recorded on film presently is being studied. This must be done by means of a dissecting microscope, since projection of the film does not allow precise age determination.

Various pellet groups have been collected, and are being examined by a parasitologist for eggs.

Plans for the coming year include a survey of lambing grounds and a trial at counting lambs. Time-lapse cameras will be placed on springs in the summer in order to obtain additional information on the population.

# # #

DESERT LAND-USE MANAGEMENT IN CALIFORNIA--ITS ECOLOGICAL AND SOCIOLOGICAL CONSEQUENCES

INVESTIGATORS:	Russell O. Davis) Keith Justice) University of California, Irvine
SUMMARY OF PROGRESS:	A final report of our findings will be submitted by Keith Justice shortly after 1 January 1975.

# # #

THE ECOLOGY OF THE JOSHUA TREE IN JOSHUA TREE NATIONAL MONUMENT

INVESTIGATOR:	James T. Hogan University of Nevada
SUMMARY OF PROGRESS:	Actual field work began in June 1974. The following components of the environment were studied: climate, soils, and vegetation.

Climatic data are being received from eight weather stations located throughout the monument.

Station No. 1 is located 3.3 miles south from the monument entrance on Utah Trail Rd. The elevation is approximately 3400 ft.
Station No. 2 is located in Pleasant Valley 5.8 miles south from Squaw Tank. The elevation is 3820 ft.
Station No. 3 is approximately 0.25 miles northwest from the Lost Horse Mine. The elevation is 4900 ft.
Station No. 4 is located in Lost Horse Valley, approximately 1.2 miles northwest of Cap Rock. The elevation is 4260 ft.
Station No. 5 is 0.8 miles south from the monument entrance at Joshua Tree. The elevation is 3450 ft.
Station No. 6 is located 0.2 miles south from the Eurika Peak turnaround. The elevation is 5200 ft.
Station No. 7 is 0.5 miles northwest of the turnaround at the Upper Covington Flats Rd. The elevation is 4880 ft.
Station No. 8 is located 0.95 miles south from the Covington Flats entrance. The elevation is 4280 ft.

Each weather station is composed of a rain guage, a 7-day continuous recording thermograph, and a maximum-minimum thermometer.

The soils collected have been analyzed for field capacity, actual moisture at the time of sampling, and pH. Further analysis will include particle size, percentages of essential elements, color, and carbon content.

Two methods of vegetational analysis are being employed for this study. The step point method is being used to obtain a general picture of the structure of the different plant communities. In this method the investigator paces through a stand and records each plant or bare area touched by a mark on his boot toe. These data can be converted to percent cover by the formula:

$$\frac{\text{number of times a species or bare area is hit}}{\text{total number of hits recorded}} \times 100 = \%\ \text{cover}$$

Fifty-one step point transects have been completed to date. Nearly all areas have been covered by this method thus far. The quarter method, as described by Phillips (1959), is being used for the analysis of tree species. Data from these analyses yield the following results: frequency, importance value, density, mean area occupied by an individual, total basal area, dominance, and mean distance between individuals. Plant collections have been made of all plant species found in a flowering condition.

Future plans include the completion of soil analysis, completion of quarter method and step point samples, reduction and analysis of the transect data already obtained, and further plant collections and identifications.

# # #

KATMAI NATIONAL MONUMENT

MOOSE POPULATION SURVEY

INVESTIGATOR: Alaska Department of Fish and Game

SUMMARY OF PROGRESS: Each year the Alaska Department of Fish and Game conducts a composition count of moose in the Angle-Takayoto drainage within the Katmai National Monument. These counts serve as a comparison to counts in heavily hunted areas on the Alaska Peninsula.

This year 362 moose were tabulated in 2 hours and 35 minutes of flying. A total of 82 bulls, 43 calves, and 237 cows were seen. The calf ratio was 18.1 calves per 100 cows which is higher than it has been for the past 4 years. The bull:cow ratio has been steadily decreasing since 1969 and is down from 93.6 bulls per 100 cows to 34.6 per 100 cows this year. The investigator attributes this to some poaching in the monument and increasing hunting pressure just outside of the boundary.

# # #

TRAPPING FOR SMALL MAMMALS IN KATMAI NATIONAL MONUMENT, JULY 1973

INVESTIGATOR: Carol R. Dennis

SUMMARY OF PROGRESS: Three different areas of Katmai National Monument were sampled for small mammal populations in the summer of 1973. This was a short term preliminary study to assess relative abundance and species distribution.

Snap traps were used in three locations of Katmai. The first location was near Fure's Cabin in the Bay of Islands, Naknek Lake; the second location was near Devil's Cove on Kukak Bay; and the third location was near the Overlook Cabin by the Valley of 10,000 Smokes.

In 530 trap nights 32 animals were caught. Two of the 32 animals belonged to the genus *Microtus* and the remaining 30 animals were members of the genus *Clethrionomys*. Two age classes, juvenile and adult, (as determined by length and sexual characteristics) were recognized in the trapped samples. Of six sites trapped, one site produced three to seven times more animals than the other sites. Possible explanations include: (1) population peak of cycle, (2) superior habitat, and (3) alteration of habitat due to human habitation.

Recommendations for future studies were made.

# # #

EAGLE NESTING SURVEY

INVESTIGATOR: Will Troyer
National Park Service

SUMMARY OF PROGRESS: A bald eagle nesting survey was conducted in the Katmai National Monument and adjacent areas on 15 May and 1 and 2 June. A total of 57 active nests and 21 inactive nests were located in 13 hours of flying time. All but 12 of the active nests were found in the existing monument. A total of 106 eagles were seen during the survey. Of the 57 nests, 28 were located on cliffs, 20 in balsam poplar, and 9 in spruce trees.

# # #

BEAR DENNING SURVEY

INVESTIGATOR: Will Troyer
National Park Service

SUMMARY OF PROGRESS: An aerial brown bear denning survey was conducted in the Katmai National Monument and in the proposed north and south extension from 25 April to 30 May. The objective of the survey was to determine the density and distribution of bear denning in this region.

A total of 232 dens were located. Major concentrations were found on Mount Dumpling, Mount La Gorce, along the Savonoski River, north of Lake Colville and Lake Grosvenor, Kamishak Drainage, Contact Creek, Puale Bay, Douglas River, and on the island in Becharof Lake.

Seventy percent of the dens were between the 500-1500 ft elevation, but varied from 25 to 2800 ft. South-facing slopes were the most commonly used. Dens were usually located on well-drained slopes and at the base of alder patches.

# # #

HUMAN IMPACT ON NATURAL VEGETATION
KATM-N-20

INVESTIGATOR: John G. Dennis
National Park Service

SUMMARY OF PROGRESS: Collection of data for the Brooks Camp annual soil temperature curve continued through 1974. The contractor for the Brooks Camp utility system installation requested and was given a set of the temperature data and a copy of the rough graph.

A series of black and white photographs was made in Brooks Camp in June, prior to any construction. A second series was made in September, after construction had begun. These photogrpahs will document, for selected scenes, the impact on Brooks Camp of reconstructing the utility system.

A trip to Hallo Bay 6-8 June permitted some early season observations of soil temperatures on the Pacific side of the monument. Minimum thaw measured was 28 cm in an 85+-year-old stand of Sitka spruce, maximum thaw was greater than 110 cm in an open, 25-30-year-old Sitka spruce stand that was invading a sandy beach ridge. The maximum soil temperature at a depth of 90 cm was 2°C, measured in sandy soil under a grass-sedge marsh next to the above-mentioned beach ridge.

Late August to early September, measurements of soil temperatures were made near Lake 592, in the southwest portion of the monument; at Fure's Cabin, in the lake portion of the monument; and west of the monument on the moraine that dams Naknek Lake and on the plain west of that moraine. Near Lake 592, the maximum soil temperature measured at a depth of 90 cm was 6.5°C under a balsam poplar grove. The minimum soil temperature measured in the Lake 592 area was 0.5°C at a depth of 79 cm in a wet, dwarf shrub bog at about 900 ft elevation. The soil was frozen below the 79 cm depth. At Fure's Cabin, frozen ground occurred at a depth of 88 cm under a thick stand of bluejoint grass, and at 63 cm under the thick moss layer of a white spruce stand. The soil under a 30-40-year-old balsam poplar stand had no frozen ground to a depth of at least 134 cm, at which depth the soil temperature was 3.0°C. Soils on the west end moraine were as warm as 5.5°C at a depth of 90 cm, whereas the soil under tussock tundra on the adjacent plain was frozen at a depth of 66 cm.

A fire of probably light intensity occurred in the area around Fure's Cabin sometime in the late 1920s or early 1930s, probably after construction of the cabin had been started. This fire may have burned through as much as about 1 ha of woods. A much larger fire burned through the area between King Salmon and the moraine at the west end of Naknek Lake in the early 1940s. A brief survey in September 1974 of the morainal portion of this burned area indicated that white spruce probably had invaded the area successfully during only one period since the fire. This invasion created a very open and sporadically distributed stand of spruce that now is about 19 to 26 years old.

Two sets of vehicle paths in the west end area were surveyed, one on the moraine, the other at the west toe of the moraine. Where the preexisting vegetation had been dwarf shrub tundra, the shoots of the dominant dwarf shrubs had been killed, but not macerated, and new sprouts had started to fill in the areas of dead shoots. The path on the moraine in one place had 118% vascular plant and 20% cryptogam cover in the untraveled centerline, but only 33% vascular plant and 6% cryptogam cover in the traveled tracks. This path in another place was totally denuded of vegetation where the path made a bend on a thinly vegetated ridge. It is possible that the path on the moraine was about 3 years old and the path at the toe of the moraine was as much as 8 years old. There are no data on frequency or type of use or on when either path was last used.

SIGNIFICANT FINDINGS: The soil temperature data reinforce the conclusion made last year that detailed soils analyses should be made prior to initiation of development or concentrated use of areas along the shoreline of Naknek Lake.

The observations on past burns indicate that the Katmai area from time to time may become susceptible to wildfire, and that post-fire succession may proceed very slowly.

The observations on vehicle paths suggest that recovery from disturbance to tundra in the Katmai area may take as long as recovery from such disturbances to tundra in other areas of the state.

RECOMMENDATIONS: The work should proceed. Support should be increased to permit the more intensive field study required to ensure having data available when needed for management purposes.

# # #

VEGETATION MAP OF KATMAI NATIONAL MONUMENT
KATM-N-18

INVESTIGATOR: John G. Dennis
National Park Service

SUMMARY OF PROGRESS: Work on the Katmai vegetation map during 1974 consisted entirely of field reconnaissance visits to Hallo Bay, Lake 592 in the southwest portion of the monument, Fure's Cabin, Brooks Camp, and the west end moraine.

Vegetation in the Hallo bay area includes Sitka spruce forest (*Picae sitchensis*), balsam poplar forest (*Populus balsamifera*), willow (*Salix* spp.) thicket, low shrub (*Myrica gale*), sedge (*Carex* spp.) marsh, and dwarf heath shrub (*Empetrum nigrum, Vaccinium uliginosum*) thicket. Of two spruce forests examined, the older was an 85+-year-old, 12 to 15-m tall stand on the north side of Hallo Creek. Reproduction of spruce under this forest appears to be slow, judging from heights and ages of two seedlings (27 cm tall, 8 years; 86 cm tall, 27 years). The younger spruce forest, on a beach ridge several hundred meters from the ocean, was a more open stand of mixed aged trees. The tallest tree sampled was 6.3 m tall, 28+ years old; the shortest was 1.9 m tall, about 18 years old. A more extensive spruce forest south of Hallo Creek was not visited but from across the creek part of it appeared to be from 5 to 15 m taller than the 85+-year-old stand that was visited.

Ash thicknesses in the area visited ranged from 25 to 56 cm.

Vegetation in the area around Lake 592 consists primarily of tall alder-willow shrub, dwarf shrub, fellfield, and wet sedge tundras. There are several groves of balsam poplar (*Populus balsamifera*) that contain fairly typical, 80-100-cm-tall grass-forb understories dominated by bluejoint grass (*Calamagrostis canadensis*) and tall fireweed (*Epilobium angustifolium*). The balsam poplar trees are 6-7 m tall, approximately 30-40+ years old. The hill south of Lake 592 has a few scattered white spruce (*Picea glauca*) trees which are approximately 13 miles south of the presently southernmost closed stand of spruce on the Alaska Peninsula. Heights and approximate ages for four of these spruce trees are: 2.5 m, 28+ years; 2.2 m, 27+ years; 1.2 m, 31+ years; and 0.7 m, 32 years.

Vegetation in the vicinity of Fure's Cabin consists primarily of white spruce, balsam poplar, and birch (*Betula kenaica*) forest. There also are alder-willow boggy areas and patches of bluejoint grassland. This vegetation covers a slope that has up to 8-9 topographic benches which, based on data of Table 1, may support a diversity of soils. Between 11 and 28 cm of ash fell in this area as a result of the eruption of 1912.

The beach at Fure's Cabin is composed primarily of large rocks and boulders. Sandy beaches occur at sporadic intervals. The vegetated fringes of several of these sandy beaches have soil profiles that include up to 12 cm of sand overlying as much as 20 cm of ash. A white spruce growing near one beach in the zone where sand overlies ash was 10.2 m tall, 44+ years old; whereas a white spruce at the same beach but farther back from the water's edge, in a zone having no sand over the ash layer, was 14.9 m tall, 88+ years old. On a large boulder in the water near this beach, the watermark of the apparently current highest water level was 55 cm above the actual water line on 31 August 1974, and an apparent former shoreline nearby was approximately 105 cm above the actual water line. The maximum fetch perpendicular to this particular beach is about 1 mile, that parallel to the beach extends over lengths of about 3 miles of uninterrupted water and 33 miles of total water surface.

The lakeshore at Brooks Camp shows a similar feature of sand overlying ash in the zone behind the present active beach. The fetch distances are greater than at Fure's Cabin, being 4 miles of uninterrupted water perpendicular to the beach plus 12 miles of partially obstructed water that lies in a direction not quite perpendicular to the beach. The vertical distance between the water line and the upper edge of unvegetated beach was about 1.75 m in mid- to late August 1974. That between the upper edge of the beach and the still higher contact zone between sand overlying ash and organic duff overyling ash was about 0.75 m.

The vegetation in the area west of the present monument boundary is, on the moraine, a mosaic of lichen, dwarf shrub, and tall shrub tundra; open, young spruce forest; and sedge marsh. On the plain west of the moraine there is a mixture of spruce forest; tall shrub and dwarf shrub tundra; and tussock tundra (*Eriophorum vaginatum*). Some of the spruce forest escaped burning during the fire that occurred in the early 1940s. The remainder of the spruce forest consists of standing or fallen dead spruce plus scattered spruce reproduction, scattered birch or willow, and a heath shrub understory. Spruce heights and ages include: (1) near King Salmon, 9.3 m, 100+ years; 5.1 m, 59+ years; 3.25 m, 25 years; (2) on the plain, 10.7 m, 122+ years; 2.3 m, 21+ years; 0.6 m, 25± years; and (3) on the moraine, 4.3 m, 23+ years; 1.9 m, 22+ years; 1.2 m, 19± years; 0.8 m, 26± years; and 0.7 m, 27 years.

Thickness of the Katmai ash layer is 1-2 cm on both the moraine and the adjacent plain.

SIGNIFICANT FINDINGS: Tree growth characteristics and age distributions suggest the possibility that in places the forests of Katmai undergo replacement intermittently rather than continuously, that the edges of distributions of tree species are diffuse, and that this diffuseness is due to infrequent, chance events. The site/soil/vegetation relationships identified at Fure's Cabin suggest the possibility that vegetational patterns directly reflect underlying distributions of different soil types. The apparent change of lake level shortly after the eruption of 1912 suggests that the lake system may be more dynamic than might be expected.

RECOMMENDATIONS: The work should proceed. Support should be increased to permit intensive investigations of such problems as the relationship of vegetation to soils in the Fure's Cabin area, since an understanding of such problems will permit a wider application of the vegetation map to management needs for planning, resource management, and interpretation. In addition, study should begin on lake level changes and the hydrology of the Naknek watershed to ensure having data available for future transportation studies.

Table 1. SOIL PROFILES NEAR FURE'S CABIN. LATE SUMMER, 1974

Suppressed, 150+-year-old *Picea glauca* forest		30- to 40-year old *Populus balsamifera* forest		Bluejoint meadow	
Horizon	Depth (cm)	Horizon	Depth (cm)	Horizon	Depth (cm)
Moss mat	0-14	Brown-black organic	0-6	Brown organic	0-8
Black, organic	14-16	Gray ash	6-34	Gray ash	8-24
Gray, ash	16-27	Brown-black organic	34-36	Brown-black humic clay	24-29
Red, organic	27-29	Brown sandy silt	36-47	Light brown sandy silt	29-33
Black, organic	29-33	Black humic clay, rocks at base	47-54	Brown-black humic clay	33-54
Compression	30	Red yellow brown gritty silt	54-74	Brown-black humic clay with stones	54-64
Frozen at	63	Light yellow brown sand, some pebbles	74-94	Pebbles, stones, water	64-69+
		Brown silt clay underlain by sand and rocks	94-114+	Frozen at	88
		Not frozen at	134		

# # #

LAKE MEAD NATIONAL RECREATION AREA

A BASIC RESOURCES INVENTORY OF LAKE MEAD NATIONAL RECREATION AREA

INVESTIGATORS: Wesley Niles) University of Nevada
Charles L. Douglas)

SUMMARY OF PROGRESS: The literature search began in late May 1974 through CPSU funding. The bibliographic materials were compiled, and species accounts from the literature were prepared. Locality information for each species was recorded and compiled. We presently are editing the manuscript in preparation for publishing, shortly after the first of the year. Owing to the vagaries of research funding, it was judged that this preliminary information should be made available as soon as possible, rather than waiting until other final reports are available on plants, birds, mammals, amphibians, and reptiles.

Numerous field trips were conducted by the research team during the summer of 1974. Most collecting was done on the Shivwits Plateau during the hot summer months. Collecting in the autumn has been conducted at lower elevations. Approximately 500 species of plants have been collected from various parts of the monument. Substantial new information has been obtained on plant and animal distributions on each field collecting trip.

# # #

RIVER MOUNTAIN BIGHORN STUDY

INVESTIGATORS: Jack Cooper) Nevada Fish and Game Department
Robert McQuivey)
David J. McLean)
William S. Worthington) National Park Service
Normen J. Reigle)

SUMMARY OF PROGRESS: After two trapping seasons, a total of 35 bighorn sheep have been marked and released back into the population in the River Mountains. The population structure of these sheep is described as follows:

Adult Rams	15	(Age class breakdown includes nine yearlings, one 2-year- (old, one 3-year-old, three 5-year-olds, and one 6-year-old.
Adult Ewes	9	Includes two yearlings and seven adults.
Ram Lambs	7	
Ewe Lambs	4	

General Observations. 1. There is a current total of 150 observations on the 12 animals marked in 1973. There is an additional 52 sightings so far on the 23 animals marked in 1974.

2. Eleven of the 12 animals marked during 1973 were observed on at least one occassion after being released. Only one animal (a ram) was not seen again. It is interesting to note that another ram that had not been observed since being trapped in 1973 was observed in September (vanished for 15 months).

3. Nine of the 12 animals marked in 1973 were observed during the summer of 1974. Carry-over appears to have been very good.

4. Preliminary work with the lincoln index has placed the average population on the River Mountains at 302 animals. This includes both helicopter and ground survey information.

# # #

LAKE MEREDITH RECREATION AREA

PETROGRAPHY AND PETROGENESIS OF THE ALIBATES DOLOMITE AND ASSOCIATED CHERT

LAMR-N-2621

INVESTIGATOR: Roger L. Bowers
The University of Texas at Arlington

SUMMARY OF PROGRESS: All field work was completed during 1974. This includes measuring, sampling, and describing stratigraphic sections of Alibates Dolomite and noting significant field relationships with other rock units. Laboratory work is about 75% complete. Fifteen samples of dolomite and flint were chemically analyzed by the Bureau of Economic Geology at the University of Texas at Austin. One hundred thin sections of dolomite, flint, and red beds have been made and are now being described. Aerial photos of the Alibates flint quarries area are being evaluated for possible clues to controlling factors for localization of the flint in the dolomite. Selected flint samples are being prepared for comparative analysis with flints from other parts of the United States.

Almost all evidence found so far strongly supports a replacement origin for most of the flint. A paper summarizing results of preliminary research was presented to the South-Central Section of the Geological Society of America in March 1974.

I recommend that no changes in the course of investigation be made at this time. Research has reached a stage where thorough evaluation of all data accumulated is needed before planning any further research.

# # #

ARCHAEOLOGICAL ASSESSMENT OF ALIBATES NATIONAL MONUMENT, ARCHAEOLOGICAL ASSESSMENT OF LAKE MEREDITH RECREATION AREA

LAMR-N-2621

INVESTIGATORS: S. Alan Skinner) Southern Methodist University
C. Britt Bousman)

SUMMARY OF PROGRESS: An assessment of the archaeological literature and recorded sites within the areas of Alibates National Monument and Lake Meredith Recreation Area resulted in a report stating the periods of occupation of these areas, the relevant literature, and recommendations for future work which will help clarify the occupational sequence, resource utilization, settlement patterns, and contact with other prehistoric groups.

# # #

RESEARCH ON WALLEYE PERCH

INVESTIGATORS: Joseph E. Kraai) Texas Parks and Wildlife Department
John Prentice)

SUMMARY OF PROGRESS: A final report was submitted on this job 15 November 1974. Information from this study can be found in Federal Aid Project F-7-R-23, Final Report, Walleye Life History Study, Region I-A Fisheries Studies, 15 November 1974.

# # #

PIPELINE SURVEY AND SALVAGE IN ALIBATES NATIONAL MONUMENT

INVESTIGATORS: Jack T. Hughes) West Texas State University
Kim E. Taylor)

SUMMARY OF PROGRESS: The survey was completed and reported. The salvage field work is completed and the report is in final stages of preparation.

# # #

LASSEN VOLCANIC NATIONAL PARK

PLEISTOCENE GLACIATION OF THE LASSEN VOLCANIC NATIONAL PARK AREA

INVESTIGATOR: Phillip S. Kane
University of California, Berkeley

SUMMARY OF CONCLUSIONS: The main conclusions from my study of the park area are as follows:

I. Conclusions regarding till age determinations.

A. Stratigraphic criteria, especially moraine nesting and the geometric continuity of moraines, are useful age discrimination criteria for the park area tills;
B. some time-dependent criteria that have been successfully used on the granitic tills of the Sierra Nevada are impractical for the volcanic tills of the park area; these criteria include boulder frequency counts and boulder weathering ratios;
C. till soil characteristics are the most useful criteria; thickness of weathering rinds on till stones, color and depth of oxidation, and particle-size distribution of sands all prove to be valuable age discrimination characteristics;
D. in regard to particle-size distribution of sand fractions, wet sieving of soil samples is essential for valid results.

II. Conclusions regarding the glaciation of the Lassen Volcanic National Park area:

A. Five ages of till are identified in the park area; from oldest to youngest, pre-Tahoe, Tahoe, Tahoe (Young), Tioga, and Late Tioga;
B. Tahoe and Tioga tills are extensively preserved; pre-Tahoe deposits occur as scattered patches in the western park area, Tahoe (Young) is identified in four widely

separated valleys, and Late Tioga till occurs as cirque moraines on the higher mountains in the western part of the park;

C. Tahoe glaciers covered about 985 km^2 (380 $mile^2$) and Tioga glaciers covered about 675 km^2 (260 $mile^2$);

D. both Tahoe and Tioga ice spread in a generally radial pattern from an "icecap" centered over the park; the main ice divide trended approximately east-west, running from Brokeoff Volcano, along Reading Peak, across the Central Plateau via Crater Butte to Saddle Mountain, and hence to the Eastern Ridges;

E. the Wisconsin (Tahoe and Tioga) ice divides correspond almost exactly with present-day drainage divides; there was only minor glacial ice "piracy" or divide-breaching by glaciers;

F. Tioga ice depth on the Central Plateau was not more than about 100 m (a few hundred feet), but in the valleys of the north fork of Bailey Creek, Mill Creek, and Warner Creek glacier lobes exceeded depths of 430 m (1400 ft);

G. the Wisconsin (Tahoe and Tioga) regional snowline was at about 2300 m (7500 ft) in the western park area, based on cirque floor elevations and the elevations of unglaciated peaks; it rose towards the northeast at a gradient of approximately 12 m/km (65 ft/mile);

H. the Late Tioga regional snowline was about 365 m (1200 ft) higher than the Wisconsin (Tahoe and Tioga) snowline;

I. amounts of glacial erosion are difficult to infer, but some localities in the north fork of Bailey Creek and Mill Creek indicate 185-275 m (600-900 ft) of valley deepening due to Pleistocene glaciations; in addition, 100 m or so (a few hundred feet or so) of bedrock were stripped by glaciers from the upper flanks of Brokeoff Volcano.

III. Conclusions regarding the correlation of the Lassen Volcanic National Park area tills with other tills in California.

On the basis of moraine morphologies and till soil characteristics, the five ages of till identified in the park area correlate with other tills in California as suggested in Table 1 (page 210).

IV. Conclusions regarding some volcanic events:

A. Post-Tahoe volcanic products hide much of the till in the northern park area, making it difficult to delineate the limits of Tahoe (and to some extent, of Tioga) ice;

B. a late glacial age is substantiated for the time of emplacement of Lassen Peak; this is in agreement with an age of "about 11,000 years" assigned by Crandell and Mullineaux (1970);

C. Brokeoff "caldera," occupying the park's southwest corner, seems to be more the result of differential erosion by glaciers (and secondarily, by streams) rather than a collapse feature as proposed by Williams (1932).

# # #

Table 1. PROVISIONAL PLEISTOCENE GLACIAL SEQUENCE FOR THE SIERRA NEVADA AND TRINITY ALPS AND SUGGESTED CORRELATIONS WITH THE LASSEN VOLCANIC NATIONAL PARK TILLS

Approximate years B.P. (in thousands) for the central and southern Sierra Nevada (adapted from Birkeland et al. 1971; Sharp 1972)	Central and southern Sierra Nevada (Blackwelder 1931; Sharp and Birman 1963; Birman 1964; Curry 1966)	Trinity Alps (Sharp 1960)	Truckee area (Birkeland 1964)	Suggested correlations of the Lassen Volcanic National Park area tills (this report, and modified from Crandell 1972)
between 9 to 11	Hilgard		Frog Lake	Late Tioga
between 11 to 25	Tioga	Morris Meadow	Tioga	Tioga
between 25 to 29	Tenaya			
		Rush Creek		Tahoe (Young)
between 45 and 55	Tahoe		Tahoe	
		Alpine Lake		Tahoe
between 70 and 130	Mono Basin			
about 400	Casa Diablo	Swift Creek	Donner Lake	pre-Tahoe
about 750	Sherwin		Hobart	
younger than 2500	McGee			
between 2700 and 3100	Deadman Pass			

LAVA BEDS NATIONAL MONUMENT

RESOURSES STUDY PROBLEM: WILDLIFE RANGE STUDIES
LABE-N-9A

INVESTIGATOR: James A. Blaisdell
National Park Service

OBJECTIVES: Range trends and forage utilization have been monitored since 1962 with new pellet counting plots being installed in 1969. Objective of these studies has been to collect data upon which to estimate range use by browsing animals. Should range resources become out of balance with the deer herds using the areas, it is essential that some form of management be initiated to either produce more natural feed or to control the number of deer on the area. Natural controls exist only to a small degree in this area of high human use. The objectives are:

1. Continue to read range utilization and pellet transects fall and spring; ground cover transects every five years.
2. Evaluate data collected and relate it to park management and interpretation.
3. Make data available to the California Department of Fish and Game for use in deer management activities outside the monument.
4. As time allows, capture and mark deer for migration and summer range studies. (Definition of summer range of these herds has never been accomplished.)

METHODS: Parker three-step method permanent transects are utilized for determination of ground cover percentages and bitterbrush utilization. Pellet count plots consist of 32 clusters of ten 1/100-acre circles, permanently placed, and cleared with each count.

RESULTS AND DISCUSSION: During the past three winters (1970-71 through 1973-74), bitterbrush utilization has run between 5 and 20% of the annual growth. This is a safe range. Pellet counts indicate a deer population of 1500-2500, with no significant highs or lows. Except for the early days of the study (1960s), deer populations have not exceeded their range carrying capacity.

CONCLUSIONS: Data needed for management of the Lava Beds deer herd is easily gained utilizing these range measurement methods. The state may find useful information in our reports.

PLANS FOR 1975: This is a continuing program, and we will continue to run both spring and fall surveys in the future.

# # #

RESOURCES STUDY PROBLEM: HABITAT RESTORATION--PETROGLYPHS SECTION
LABE-N-14

INVESTIGATOR: James A. Blaisdell
National Park Service

OBJECTIVES: Vegetation in the immediate vicinity of the petroglyphs has deteriorated by the continued use of vehicles and by the trampling of foot traffic. A means to reestablish native plants needs to be found.

METHODS: Abolish all traffic and create walkways by the arrangement of natural rock. Test-plant native grass seed and transplant native shrubs.

RESULTS AND DISCUSSION: Park personnel have partially eliminated further wear to the area by the placement of rock in the roadways and over the remainder of the area. Little progress has been made in reestablishing the plants. This needs to be done to prevent the wind from blowing sand into the petroglyphs' wall. Much of the area is solid rock and cannot be planted but some work can be accomplished.

CONCLUSIONS: Little research has been accomplished; park managers have accomplished a large amount of work but more is needed.

PLANS FOR 1975: Hopefully, some research into possible planting species and procedures can be accomplished.

# # #

RESOURCES STUDY PROBLEM:
EXOTIC PLANT IDENTIFICATION AND RECOMMENDED CONTROL
LABE-N-24

INVESTIGATOR: James A. Blaisdell
National Park Service

OBJECTIVES: Nonnative plants have become established in the monument. Some are known, others probably are present and need identification. Recommended control procedures are needed.

METHODS: With the assistance of experts in the fields of plant identification and weed control, determine what plants are exotic and what procedure is recommended for their control.

RESULTS AND DISCUSSION: To date, advice has been obtained from W. B. McHenry, University of California at Davis; Ken Baghott, University of California, Tulelake farm advisor; and James Young, Agricultural Research Service, Reno. These gentlemen so far have concerned themselves mostly with mullein control although some thought is being given to determining what the seral and pristine plant communities looked like and what type of vegetative cover we should be headed for.

Some control work for mullein has been accomplished by the park staff. This has consisted of spot-spraying with a 2,4-D Amine mixed with oil and a wetting agent. Control was only fair; it is felt that the plants attained too large a size prior to treatment.

Some thought is being given to combining this study with the Prescribed Burning Study in that prescribed burning may produce vegetative situations in which exotic plants either are or are not encouraged.

CONCLUSIONS: Some progress has been experienced; much more needs to be done.

PLANS FOR 1975: Continue to identify plants, and to work with experts in the field.

# # #

RESOURCES STUDY PROBLEM: WILD FIRE NATURAL REVEGETATION STUDIES
LABE-N-25

INVESTIGATOR: James A. Blaisdell
National Park Service

OBJECTIVES: Determine natural replacement plant species, both native and exotic, to areas burned by varying intensities of wild fires. Data may be utilized for park management and in conjuction with RSP LABE-N-16, 17, 18, prescribed fire in three different plant communities.

METHODS: Establish ground-cover transects in areas burned by varying intensities of wild fire. Two hot burns are already available. Eight new transects and three older transects that were in one fire's path are now being read annually.

RESULTS AND DISCUSSION: Transects were installed in the Lava Burn and the Bighorn Burn (inside the bighorn enclosure) in August 1973. Because the burns were of extremely intense temperatures, burned areas read 100% nonproductive or dead cover. Unburned areas adjacent to the burned ones ran varied in percentages, but ran 40-52% productive cover. The transects were read again in August 1974; results of the survey are not as yet available. Observations in these areas illustrate a return to increased perennial grasses and to forbs. One browse species, choke cherry (*Prunus virginiana*) is also obvious in the Lava Burn.

CONCLUSIONS: Wild fires will revegetate within a very short period. Original browse species and some forbs will be some time in reappearing (if ever). From the first year's study it appears perennial grasses will benefit the most. This, if it continues, will also benefit some of the recently extirpated or rare wildlife species.

PLANS FOR 1975: Continue to read transects annually. Establish more transects in new burns.

# # #

RESOURCES STUDY PROBLEM: BIGHORN REESTABLISHMENT STUDIES
LABE-N-12A

INVESTIGATOR: James A. Blaisdell
National Park Service

OBJECTIVES: With the completion of LABE-N-12 (Reintroduction of Bighorn) extended and more intensive studies of the resultant bighorn transplant are necessary. Success of the reestablishment attempt will depend upon many factors, all of which are included in the research. These are:

1. Loss of bighorn through natural or unnatural causes.
2. Reproduction.
3. Survival of lambs.
4. Range use, trends, and carrying capacity according to population increases.
5. Diseases, parasites, predation, poaching.
6. Water consumption and needs for added supply.
7. Competition with other species, including man.
8. Food habits and mineral requirements.
9. Study social behavior of bighorn sheep as it affects herd migrations and selection of new habitat.

METHODS: Observations, both by this investigator and Lava Beds personnel, have been instrumental in supplying data and in determining activities of the herd. Regular inspection of the 1100-acre enclosure and its three water devices have held to a minimum any maintenance needed. Salt was made available at waterholes, and time-lapse photography was used to determine use of water, medicine and salt. Pathologists at the California Department of Fish and Game laboratory and Oregon State University were utilized to identify disease and prevent further losses.

RESULTS AND DISCUSSION: The population of bighorn in the enclosure at Lava Beds hit a high of 22 animals with the birth of 5 lambs from 7 ewes in the spring of 1974. By the end of October 1974, the herd had been reduced to 15 animals. The loss was the result of the virus disease bluetongue or epizootic hemorrhagic disease which accounted for six deaths. The 3.5-year-old ram, transplanted in December 1973 from Nevada, disappeared without trace. We reported last year the presence of bluetongue in the deer near Keno, Oregon. Since that time, we have been apprised of the fact that the virus is present in several southern Oregon and northern California domestic sheep herds. It is carried by the gnat *culicoides*, and outbreaks usually occur during long hot, dry summers and falls. We presently have 6 ewes of breeding age. By spring our population should be back up to 21, depending upon lamb production.

Lambing season in 1972 and 1973 was entirely within the month of May. In 1974, all five lambs were born during April. This is typical of animals moved to more southerly latitudes. It will be interesting to note birth dates in 1975.

Near the end of the bluetongue epizootic, several of the bighorn displayed coughs. To prevent losses to disease-weakened animals, two of the waterholes were blocked, and the third one treated with Sulmet (sodium sulfa-methazine). Wild raspberry jello was utilized as an attractant. Time-lapse movies proved that the entire band was treated as well as several deer and a porcupine!

During the summer, a large salt block was placed near the central water source. Again, the time-lapse movies illustrated heavy use of salt, usually after drinking. Its necessity is unknown, but the sheep certainly utilized it.

Public relations is mostly in the form of news articles, talks before professional societies, and other groups. Also, during 1974-75, the writer presented papers before the annual banquet of the Society for the Conservation of Bighorn Sheep in Los Angeles, and the NASA-NPS Research Center Interdisciplinary Symposium at Bay St. Louis, Mississippi.

CONCLUSIONS: Losses during 1974 were extreme, and, it is hoped, unusual. A successful 1975 lambing season, hopefully without a disease outbreak, will bring up the population to where it was last fall. Eventual release of surplus animals will obviously be held up a year or two.

PLANS FOR 1975: Continue studies as they have been conducted the past 3 years. This is in accord with the five-agency cooperative agreement.

Publications

"Lava Beds California Bighorn, was 1973 typical?" Desert Bighorn Council Transactions 1974 (in publication).

# # #

RESOURCES OF THE PETROGLYPH SECTION AND PENINSULA
LABE-N-0022

INVESTIGATOR: Stephen Murrill
Bixby Work-Learn Students

SUMMARY OF PROGRESS: A good review of all resources is given in the final report--*Wildlife, vegetation, history, archeology, geology.* The report was presented to land agencies concerned with future land uses.

# # #

EXOTIC PLANT IDENTIFICATION, CONTROL
LABE-N-0024

INVESTIGATOR: James A. Blaisdell and consultants
National Park Service

SUMMARY OF PROGRESS: W. B. McHenry, Univeristy of California at Davis, and James Young, Agricultural Research Service, Reno, Nevada, have been consulted in regard to control of mullein, a nonnative plant. Recommendations received called for use of 2,4-D during the summer of 1974. Some effects were noted but it is felt the plants became too old and large for effective control. Future studies may involve combining this study with that of Dr. Martin, LABE-N-16, 17, 18.

# # #

WILDFIRE REVEGETATION
LABE-N-0025

INVESTIGATOR: James A. Blaisdell
National Park Service

SUMMARY OF PROGRESS: Eight new ground-cover transects and three original ones are measured annually to determine natural revegetation of the two wildfire areas (1973). One is in the headquarters area, the other in the bighorn pen. After 1 year, increases in perennial grasses are obvious. Rabbitbrush is returning, but slower than the bunch grasses. Object is to determine value of hot prescribed burns. Data can be utilized by Dr. Martin for LABE-N-16, 17, 18.

# # #

ECOLOGICAL WILDLIFE RANGE STUDIES--DEER

LABE-N-009A

INVESTIGATORS: James A. Blaisdell) National Park Service
Park Staff)

SUMMARY OF PROGRESS: Range surveys and pellet counts in 1973-74 indicated an almost static population of deer and only 5.4% utilization of bitterbrush. Growth of bitterbrush was down (average 1.5 inches in 1973, 2.0 inches in 1972). Growth in 1974 appears to be up considerably, but results of surveys are not compiled as yet. Range use was not considered damaging in 1973-74.

# # #

BIGHORN REESTABLISHMENT STUDIES

LABE-N-012A

INVESTIGATOR: James A. Blaisdell
National Park Service

SUMMARY OF PROGRESS: Population now stands at 16 animals after loss of 6 to bluetongue disease in September 1974. No conviction made on poaching incident of 1973. Five lambs born April 1974 (3 male, 2 female). Interagency cooperative study continues.

# # #

VECTOR ECOLOGY AND CONTROL STUDIES

LABE-N-0020

INVESTIGATORS: Bernard C. Nelson)
Charles R. Smith) California Department of Health
Ernest E. Lusk)

SUMMARY OF PROGRESS: In 1972-73 an epizootic of bubonic plague occurred in the rodents inhabiting caves, including those frequented by tourists. After control measures were undertaken in April 1973, no further evidence of plague occurred in the caves. Although no overt involvement of plague in surface rodents was found in 1973, a disappearance of wood rats, highly suggestive of plague involvement, occurred in 1974 near Craig Cave. Because of repeated epizootics in 1962 and 1972-73 we are monitoring the reoccupation and status of the wood rats, which are our best sentinel animal in caves, on a twice yearly basis. This long-term project may hopefully result in early recognition of future epizootics.

As requested by the National Park Service, we are applying for a grant to study bubonic plague, tick-borne diseases, mosquito-borne encephalides, and rabies in bats at the monument. In anticipation of the grant, we began surveys of ticks and mosquitos in 1974. Although no pathogens were isolated from the material collected, we established that the major vector of tick-borne diseases, *Dermacentor andersoni*, and the major vector of encephalides in California, *Culex tarsalis*, occur at the monument and breed near the headquarters area.

Publications

Nelson, B. C., and C. R. Smith. 1974. Intra- and interspecific territoriality exhibited by *Spermophilus lateralis* at insecticide-bait stations during a plague epizootic. *Calif. Vector Views* 21:19-21.

Nelson, B. C., and C. R. Smith. Ecological effects of a plague epizootic on the activities of rodents inhabiting caves at Lava Beds National Monument, California. (to be submitted to *J. Mammal.*)

# # #

MAMMOTH CAVE NATIONAL PARK

HYDROLOGY OF MAMMOTH CAVE

MACA-N-0001

INVESTIGATOR: R. V. Cushman
U. S. Geological Survey

SUMMARY OF PROGRESS: The project remained in a monitoring status through 1974 but was reduced in scope considerably on 1 July 1974. Until 1 July measurements of flow, water level, and water quality were maintained at observation points which were selected so as to monitor most present and potential water supplies available to the park. The recording gages on Green River and Beaver Dam Creek and water-table recorders on two observation wells were continued in operation to monitor seasonal and long-term changes in the available supply. Discharge measurements were made periodically on Wet Prong, Buffalo Creek, Beaver Dam Creek, Bylew Creek, and Dog Creek, and on Echo and Styx river outlets, especially during periods of low flow. Sampling for chemical-quality analysis was continued periodically especially at low flow at 10 sites on streams, springs, and wells. The samples were analyzed at the Survey's Central laboratory at Doraville, Ga. and the results forwarded to the National Park Service. After 1 July the project was reduced to include only the operation of stage recording gages on Green River at the Ferry and Mount McKinley and Union City wells and the processing of the record.

Stream discharges and ground-water levels were above normal at the end of the year. No marked change in chemical quality of streams and ground water were noted.

# # #

DEER POPULATION STUDY

MACA-N-0002

INVESTIGATOR: Pete Troublefield
Department of Fish and Wildlife

SUMMARY OF PROGRESS: Herd Reduction Program. The 16th trapping season ended 31 March 1974. At that time a total of 4319 deer had been successfully transplanted throughout Kentucky. The total catch during this trapping season was 213. Of these, one was released at trap site, there were 13 mortalities, and the remaining 199 were transplanted. As of 30 November 1974, the Department of Fish and Wildlife has been inactive in the deer-trapping program. All trapping activities have been under the direction of the bureau in conjunction with their deer study being conducted in the park.

Browse Studies. The Aldous Method is used to estimate the availability and useage of browse in the park. This survey has been conducted for the past 19 years. Two browse indexes are obtained from each survey; one index for "all browsed plants" and one for "preferred plant genera." A browse index of 100 is considered the maximum degree of browsing a plant can withstand without retarding plant growth and reproduction. Over the past few years there has been a general lessening of pressure on browse on Mammoth Cave National Park. However, it must be noted that some of the preferred plant genera have all but disappeared in certain sample areas. The 1974 survey indicated a browse index of 110 for all browsed genera (minus 8 from the previous year), and an index of 227 for preferred plant genera (minus 7 from 1973). Twenty-seven or the forty-two utilized plant genera were over-browsed.

# # #

REPRODUCTION REGULATION OF WHITE-TAILED DEER IN MAMMOTH CAVE NATIONAL PARK

MACA-N-21

INVESTIGATOR: George H. Matschke
U. S. Fish and Wildlife Service

SUMMARY OF PROGRESS: Tube-type silastic^R implants containing a synthetic estrogen or progestin steroid were successful in preventing ovulation in female white-tailed deer in both a pen and a 6000-acre enclosure study at Sandusky, Ohio. Solid silastic^R rod vaginal implants impregnated with either a synthetic estrogen or progestin prevented conception. Feeding a microencapsulated estrogen every 17 days during the 1973-74 breeding season failed to prevent conception. Poor acceptance of treated bait was the cause; whether this was a taste or metabolic rejection is not known. High dosage levels of oral progestin in three different feeding regimes also failed to prevent pregnancy. Solid silastic rods, penis blockers, anchored in the vagina failed to prevent the male from ejaculating and conception by does occurred.

A new microencapsulation formulation with a synthetic estrogen was tested successfully prior to the 1974-75 breeding season on the same group of females that rejected last year's estrogen microencapsulation formulation, and on a second group of deer which consumed each of the four dose-level baits equal to the untreated bait. Three oral acceptance tests using the new microencapsulation formulation are in progress this 1974-75 breeding season. Other tests this breeding season include a tube-type ear implant efficacy test on free-ranging deer at Mammoth Cave National Park, and at NASA's facilities at Sandusky, Ohio; also at Sandusky is an implant study to determine the minimal effective dose level for tube-type implants. A mechanical birth control device used successfully in dogs is being tested at the Mammoth Cave research facilities. A test is being conducted to prematurely age the ovary and thus achieve sterility by administering high dose levels of androgens to female fawns.

Continued support is recommended for the next 3-4 fiscal years to allow the completion of the ear implant efficacy studies now in progress both at Mammoth Cave and Sandusky, Ohio. An efficacy study using the mechanical, nonchemical, birth control device should be designed for next year's breeding season, 1975-76, provided that this device demonstrates contraceptive effects this breeding season in the pens and that cooperation can be obtained from the manufacturer to produce a larger device.

During a meeting on 11 March 1974, representatives of both agencies mutually agreed to close the research facilities at Mammoth Cave by the end of FY-75 but recommended support at a reduced level to complete the above-mentioned field studies now underway. The project has been unable to develop an orally effective, chemosterilant approach for managing deer populations that meet the criterion set by management. Progestins (e.g., MGA) are not feasible because almost daily baiting is required and estrogens (e.g., DES), which are biologically more promising, are not sufficiently well accepted in bait form. If the new microencapsulated DES formulation currently under evaluation is effective this breeding season, additional research may be desirable.

# # #

WATER QUALITY IN SPRINGS & RIVERS OF THE CENTRAL KENTUCKY KARST
MACA-N-0026

INVESTIGATORS: Donald R. Rowe) Mike Holmes) Western Kentucky University, Bowling Green

SUMMARY OF PROGRESS: The principal objectives of this study were to make a reconnaissance survey to determine the major biological, chemical, and physical characteristics of ground water and surface water in the Central Kentucky Karst Region. This project was carried out by nine Western Kentucky students and extended over a period of 10 weeks.

The student project director is presently working on his final report to the National Science Foundation. This is supposed to be completed by the end of this year. In addition, the data from 27 sites at which 18 parameters were monitored is being subjected to computer analyses. We have the data punched on cards and are now trying to locate a program that will assist in our analyses of this large volume of information. If we cannot locate an already existing program for this work, we must try to develop one of our own. The final report on the computer analysis of this data will be completed by 15 May 1974.

While the data for the 27 sites has not been analyzed in detail, the parameters monitored ranged as follows:

Physical Parameters:	
Temperature ranges	12°C-24°C
Turbidity	2-109 JTU
Color	3-140 APHA
Chemical Parameters:	
pH	6.8-8.1 units
Total Residue	480-4500 mg/L
Sulphates	6-98 mg/L
Alkalinity	62-245 mg/L as $CaCO_3$
Hardness	79-255 mg/L as $CaCO_3$
Biochemical Oxygen Demand	0.2-53.2 mg/L
Dissolved Oxygen	0.5-10.3 mg/L
Phosphates	N.D.-3.5 mg/L
Nitrates	<1-73.8 mg/L
Iron (Fe)	N.D.-1.27 mg/L
Manganese (Mn)	N.D.-0.42 mg/L
Chromium (Cr)	N.D.-0.4 mg/L
Biological Parameters:	
Total Coliform	7/100 ml to 5,420,000/100 ml
Fecal Coliform	N.D. to 9293/100 ml
Fecal Streptococci	N.D. to 1,000,000/100 ml

This study has provided our students with a valuable and interesting learning experience and I think that when the results are gathered together in the final reports valuable conclusions will be made. These final reports will be mailed as soon as they are completed.

N.D. = Non-detectable

NICHE SEPARATION IN THREE SPECIES OF CAVE BEETLE (*COLEOPTERA CARABIDAE*)
MACA-N-0035

INVESTIGATOR: Thomas R. McKinney
University of Kentucky

SUMMARY OF PROGRESS: The populations of both *Pseudanophthalmus menetriesi* and *P. pubescens* in Walnut Hill Cave fluctuated during the year reaching a low point in the winter and a high point in the late summer and fall. These fluctuations were probably due to temperature differences and differences in the litter fauna due to differences in the age of the litter.

From the data gathered in this study there appeared to be a temporal separation between the appearance of teneral *P. menetriesi* and *P. pubescens*; however, other data available contradicts this. *P. menetriesi* population turnover time is about one and one-third year while *P. pubescens* population turnover time is somewhat longer, although the figure of 3 years as calculated is an overestimate.

Both *P. menetriesi* and *P. pubescens* have an aggregated distribution in the Walnut Hill Cave stream bed but the reasons for this are not clear.

When the distribution of *P. menetriesi*, *P. striatus*, and *P. pubescens* are examined from five microhabitats in three caves *P. menetriesi* has the greatest habitat breadth, *P. striatus* the least habitat breadth, and *P. pubescens* an intermediate breadth. The *P. menetriesi*-*P. striatus* pair had the least amount of habitat overlap and the *P. striatus*-*P. pubescens* pair the greatest habitat overlap.

The addition of cave litter to bare clay shelves in Parker Cave on two occasions increased the beetle populations there, with *P. pubescens* increasing more than *P. menetriesi*, as well as increasing the number of potential prey animals. On neither occasion was the critical mass of litter added to the shelves and high animal populations were not maintained.

When presented with a number of choices between different microhabitat elements, the most complex of the choices was preferred on almost every occasion. *P. menetriesi* showed the most variation in its choices of complex substrate and *P. striatus* the least variation.

When given a choice, all three species preferred the wettest of five different substrate moistures and two of the three, *P. menetriesi* and *P. pubescens* preferred the driest section the'least.

In both long-term and short-term interspecific interaction experiments *P. pubescens* appeared to be more aggressive than either *P. menetriesi* or *P. striatus* and *P. menetriesi* more aggressive than *P. striatus*.

Both *P. pubescens* and *P. striatus* readily dug holes in a clay substrate while *P. menetriesi* rarely dug. When given a choice, *P. striatus* dug significantly more holes in a substrate with surface irregularities while these irregularities effected the digging of neither *P. pubescens* or *P. menetriesi*.

There was little difference in the length of life between *P. menetriesi* and *P. pubescens*. *P. menetriesi* lived much longer in 85% relative humidity than either *P. striatus* or *P. pubescens* between which there was little difference. When immersed in water, *P. striatus* lived much longer, up to 24 hours, than either *P. menetriesi* or *P. pubescens*.

In the laboratory, *P. menetriesi* is more efficient at catching Collembola (*Folsomia* and *Sinella*) than *P. pubescens* and *P. pubescens* is more efficient than *P. striatus*. Oligochaetes are caught by *P. striatus* most efficiently and *P. menetriesi* least efficiently while *P. pubescens* is almost as efficient at catching worms as *P. striatus*. None of the three species readily ate large oribatid mites.

Food differences seem to be most important in allowing these three species to inhabit the same caves; however, habitat breadth and differences in aggressive behavior may also be important.

# # #

GEOLOGY AND GEOMORPHOLOGY OF FLOYD COLLINS' CRYSTAL CAVE
MACA-N-0037

INVESTIGATOR: Arthur N. Palmer
State University of New York, Oneonta

SUMMARY OF PROGRESS: The stratigraphic section observed in Crystal Cave was extrapolated through the major passages in other portions of the Mammoth Cave-Flint Ridge system to obtain (a) information regarding changes in rock type and thickness of rock units, (b) approximate altitude of cave passages from identification of strata exposed, and (c) interpretation of the sequence of passage development in caves of the national park.

A composite geologic column and correlation chart for the limestone units in the national park is in preparation. An analysis of the influence of local variations in stratal dip on passage orientation in Crystal Cave is being written for publication in a geological journal, and a monograph on the geology of Mammoth Cave National Park, based on field work for this project, will be published by the Cave Research Foundation. Preliminary results of the project are to appear in a forthcoming book on the hydrology of the Central Kentucky Karst, edited by William B. White of Penn State University.

Future work will include detailed hand leveling of various parts of the Mammoth-Flint Ridge Cave System for comparison with the findings in Crystal Cave, as well as laboratory and thin-section analyses of rock samples (in progress). Field work is roughly 80% completed; laboratory work is approximately 25% completed.

# # #

THE ECOLOGY OF THE *NEAPHAENOPS--HADENOECUS* PREDATORY-PREY SYSTEM
MACA-N-0036

INVESTIGATOR: Russell Norton
Yale University

SUMMARY OF PROGRESS: The chief goal of this project during 1974 has been to demonstrate the selective basis for the long-short ovipositor polymorphism in populations of the cave cricket, *Hadenoecus*. The long and short ovipositor morphs occur in *Hadenoecus* populations which live in the respective presence or absence of *Neapheanops*, a cave beetle predacious cheifly on the eggs and nymphs of *Hadenoecus*. Experiments placing *Hadenoecus* eggs at the long and short oviposition depths have failed to show any differential predation. This was not wholly unexpected since *Neaphaenops* digging behavior is presumably coevolved with the longer *Hadenoecus* ovipositors. Since *Neaphaenops* populations without *Hadenoecus* prey are unknown and are unexpected, it will be impossible to study beetle digging behavior which is not coevolved for predation on the more deeply oviposited *Hadenoecus* eggs. The next step will be to compare the digging depth of *Neaphaenops* with *Darlingtonea*, its eastern Kentucky ecological equivalent. Since *Darlingtonea* is essentially the same size as *Neaphaenops* and since the more robust eastern Kentucky *Hadenoecus* species has a longer ovipositor than the western Kentucky species, the hypothesis is that *Darlingtonea* will dig to a deeper depth than *Neaphaenops*. The result should strengthen the deomonstration that beetle digging behavior is coevolved with ovipositor morphology, since any egg oviposited at a deeper depth must have a (slightly) higher probability of not being predated. This next phase of research will be conducted outside MCNP and demonstrates the relevance of cave research outside the region to faunal studies within the park itself.

# # #

THE ECOLOGY AND EVOLUTION OF CAVE INVERTEBRATES, ESPECIALLY BEETLES
PRESENT SPECIFIC RESEARCH PROBLEM:
POPULATION GENETICS OF TROGLOBITIC *PTOMAPHAGUS* BEETLES

INVESTIGATORS:
Stewart B. Peck)
George Carmody) Carleton University, Ottawa, Canada
Cameron Laing)

SUMMARY OF PROGRESS: Analysis of genetic variability in populations of the beetle *Ptomaphagus hirtus*, some from Mammoth Cave National Park, are completed. A Master's Thesis has been written on the subject and is now being prepared for publication. A secondary study of genetic variability in *Scoterpes copei* millipedes has also been completed and is in preparation for publication.

The completion of these projects terminates the present phase of work involving Mammoth Cave National Park. We assume that additional work will be permitted in the park when funds and suitable students become available. Genetic variability studies should be done on other Mammoth Cave National Park cave organisms as well as work on other ecological-evolutionary problems.

# # #

CAVES AND KARST NORTH OF THE GREEN RIVER
MACA-N-0045

INVESTIGATOR: North Shore Task Force

SUMMARY OF PROGRESS: Survey of known caves in the Turnhole Bend Ridge is substantially complete and significant extensions have been discovered. A total of 3 miles of passage have been surveyed in five caves: Saunders, Running Branch, Bat, Ganter, and Dossey Domes. Their full extent is not yet known, but they probably will be completely surveyed in the coming year.

An unusual, we think unique, form of gypsum has been discovered in one of these caves, and its location has been given to the National Park Service. This form of gypsum occurs as elongate hemi-octahedrons as much as 13 cm in length.

# # #

ALGAE SURVEY OF SELECTED REGIONS OF MAMMOTH CAVE
MACA-N-0044

INVESTIGATOR: Robert Van Hoff

SUMMARY OF PROGRESS: All collections have been taken and identified. The final report is being prepared and will be submitted by 1 January 1975. A single alga of probable significance is being cultured for identification.

# # #

SPELEOTHEM GEOCHRONOLOGY OF NORTH AMERICA
MACA-N-0038

INVESTIGATOR: Russell S. Harmon
McMaster University, Ontario, Canada

SUMMARY OF PROGRESS: During 1974, age dating and stable isotope analysis of stalagmite 72041 (Davis Hall) was completed and resulted in the first ^{18}O-time profile for a speleothem from the continental interior of North America. Analysis of modern soda-straw stalactites and associated drip waters was completed and allowed a climatic interpreration to be placed on the ^{18}O record for sample 72041. Two other deposits, samples 74008 and 74009 (Great Onyx) are presently under study.

The purpose of this study was to investigate late Pleistocene paleoclimates of continental North America as recorded in the speleothem record. In detail, oxygen-18 and deuterium/hydrogen analyses of calcite speleothems and entrapped fluid inclusions provide a means of determining the climate and, in some cases, the absolute temperature at which the speleothem was deposited. Thus, by determining the age of a speleothem and running an axial stable isotope profile for the specimen, a paleoclimate curve can be constructed.

The central Kentucky area is unique in the 10 karst areas studied to date in that only there and in the Nahanni Region of northern Canada has speleothem material of such antiquity been consistently preserved. In all other areas speleothems older than 200,000 years B.P. are rare, whereas in central Kentucky it is rare to find material younger than 300,000 years.

The oxygen isotopic composition of a series of points along the axis of speleothem 72041 has been made. The results were plotted against age compared with the modern dripstone deposits. The ^{18}O profile is in good agreement with other speleothem results over the same time period, but the absolute amplitude of the ^{18}O variation less than for other areas presumably due to the remoteness of central Kentucky to the major North American ice sheets during the Pleistocene. The well recognized 100,000 and 180,000-200,000 years B.P. periods are prominent in the 72041 record as is the extended cold period 130,000-170,000 years B.P. (Illinoian glacial period).

A series of fluid inclusions extracted from the calcite stalagmite have been analyzed for their D/H ratios in order to determine the ^{18}O composition of the water from which the specimen was precipitated. This allows for a calculation of absolute temperature of deposition to be made based upon experimental determination of the calcite-water fractionation factor as a function of temperature. Temperatures during the Illinoian glaciation were consistently 10°C lower than present. Adjacent, warmer interglacial periods had temperatures a few degrees less than at present. This adds additional support to present speculation that the present interglacial period in which we are living is unusually warm and one that is unequalled in the Pleistocene.

Additional samples will be analyzed during the next year as the project nears completion and it is hoped that a final report will be completed within the next 12 months.

# # #

HYDROLOGIC AND GEOLOGIC STUDIES OF MAMMOTH CAVE AND THE CENTRAL KENTUCKY KARST

INVESTIGATOR: James F. Quinlan
National Park Service

SUMMARY OF PROGRESS: An intensive study has begun of the ground water, chemical hydrology, and geomorphology of Mammoth Cave National Park and the adjacent area. Preliminary results are encouraging.

SIGNIFICANT FINDINGS: 1. Sewage effluent from a service-operated treatment facility flows through Mammoth Cave and emerges 11 days later at Green River. The bacterial quality of the effluent, the route it takes, and whether another treatment facility may also discharge effluent into the caves will be studied.

2. Techniques have been developed for the use of optical brighteners in tracing sewage and groundwater in aquifers. These dyes have not been previously used for water tracing in America.

3. The occurrence of optical brighteners in certain springs, cave waters, streams, and Green River has been established. This information has been and will be used for the planning and interpretation of dye-tracing studies that will tell not only about park and regional hydrology but also about the source of pollutants in the carbonate aquifer.

4. A group of 34 springs at 10 locations in a 5-mile reach of Green River 10 miles upstream from the park has been shown to discharge heavy metals (copper, chromium, nickel, and zinc) in concentrations 2 to 20 times greater than in springs upstream or downstream from this reach or the river itself. The river is the water source for several towns and is a possible source for drinking water within the park. The heavy metals concentration of these springs is less than the maximum allowable by present state or federal standards but little is known about the carcinogenic effects of heavy metals. It is known, however, that concentrations that are "safe" for humans can be lethal, toxic, or mutagenic to certain species of fish and the "safe" concentration for one species may be much greater or less than the "safe" concentration for another species. It is not known what the potential effects upon blindfish embryos and other cave fauna might be from heavy metals in Green River water that is back-flooded into Mammoth Cave and other caves. All of the springs with anomalous heavy metals also have high concentrations of optical brighteners. Sources of metals in springs and cave streams are being studied.

5. The springs that drain the large region of the Sinkhole Plain adjacent to the east boundary of the park--as contrasted with local areas within or adjacent to the park--have now been identified. These are the 34 springs described under No. 4, above.

6. The existence of a diffuse-flow system that may be largely independent of the conduit-flow system in the carbonate aquifer has been identified. The slow but possibly inevitable dispersal of pollutants within this diffuse-flow system may be a serious threat to the park. The problem is being studied.

7. Several caves have been explored and mapped. Such data is essential for the construction of theoretical models of how water flows through the aquifer to and through the park.

8. The Glen Dean Formation has been recognized as a significant local aquifer.

9. Several dye-recovery systems for water-tracing have been designed and tested.

10. Pike Spring, a well-known double spring within the park has been shown to have one orifice that can be discharging while the other, only 15 ft away, is being back-flooded by Green River at low stages of the river. This phenomena is significant because it influences the validity of interpretations of the chemical quality of Pike Spring waters. The interpretation of water quality of the spring at Echo River is similarly influenced by Green River water that flows into Mammoth Cave at River Styx Spring and can resurge a few hours later at Echo River.

11. Strain gages have been and will be installed in the New Entrance of Mammoth Cave in order to reassess the stability of certain passages there.

PLANS FOR 1975: Location of additional springs and caves, monitoring chemical and bacteriological quality of cave, river, well, and spring waters, location and mapping of caves and terraces, synthesis and statistical analysis of data. Progress is contingent upon the availability of funds for support personnel. Meteorlogical data on parts of Mammoth Cave will be systematically collected.

# # #

MOUNT McKINLEY NATIONAL PARK

FOOD HABITS AND POPULATION DYNAMICS OF DALL SHEEP IN MOUNT MCKINLEY NATIONAL PARK

INVESTIGATOR: Kenneth Whitten

SUMMARY OF PROGRESS: Direct observation of feeding sheep indicated that they selectively took new green growth of grasses, sedges, and some forbs and shrubs. A few plants were conspicuously avoided. I collected a number of food plants for nutritional analysis. Results show that summer apline forage in McKinley National Park is rich in protein and phosphorus and has sufficient calcium and magnesium. Relative protein and phosphorus levels decline in later growth stages of plants, while calcium and usually magnesium as well, increase. By late summer, phosphorus is low and calcium to phosphorus ratios reach unsuitable levels. Winter diets are probably deficient in phosphorus and low in protein, but adequate in carbohydrates.

It appears that sheep take full advantage of the short-lived but luxuriant summer vegetation by moving to areas of highest quality (i.e., new growth) forage. All body growth is in summer, and there is weight loss in winter. Winter diets are suited for only basic body maintenance and there are probably shortages and imbalances incurred which must be corrected in spring.

After a population decline in the mid to late 1960s, park sheep now seem to be on the increase. Fluctuations in population are natural and probably cannot be controlled. Population fluctuations arise from complex interactions between weather, forage supply, and sheep density, moderated to some extent by disease and wolf predation. The latest decline and the current increase have been in the presence of a large wolf population. I doubt that wolves in themselves control the sheep population.

Up to now, sheep have been little affected by visitor use. Wild sheep are usually tolerant of human presence, but continued harassment may cause them to abandon certain ranges. During early summer, a few sheep--including some large rams--use the Polychrome Overlook area. As long as tourists do not approach them too closely, there should be no conflict. Sheep can often be seen within 50 m of the road and sometimes much closer. There should be no need for closer approach. Igloo Mountain supports a large ewe-lamb group all summer, and these are often the only sheep visible from the road after about 15 June. During the past two summers there has been heavy visitor use of Igloo Mountain. To date there has been no visible effect on sheep, but the situation should be watched closely.

Visitors have a tendency to try to get just a little bit closer for another picture, and in this manner they slowly drive sheep off their feeding pastures. The ridge between Tributary Creek and the East Fork River has been recognized by the National Park Service as a critical sheep area. Large rams use this area mainly in July and August. The ridge just north of Tributary Creek receives more ram use and is used all summer. It is probably far enough from the road to escape heavy visitor use at least at the present time. During early summer the same rams which later show up near the "Hankins" or "Ram Country" trailhead are often farther down the same ridge system, about 2.5 or 3 miles to the northwest.

I can think of no other areas where there are presently any man-sheep conflicts. There should be ample opportunity for roadside tourists to glimpse sheep at a distance and occasionally at close range. Backpackers should be able to locate sheep easily in off road areas, and with a little effort, patience, and common sense they should be able to stalk close to sheep to observe, photograph, and enjoy them for some time to come.

# # #

SCAVENGING ACTIVITIES OF ARCTIC ANIMALS

INVESTIGATOR: Audrey J. Magoun
University of Alaska

SUMMARY OF PROGRESS: One of the questions posed in the study is "What species can be expected to arrive first at a carcass?" This question has been answered for the 1972 data. Of nine carcasses where ravens were present, they were the first arrival six times, second arrival twice, and arrived first simultaneously with a gull once. Of seven carcasses where wolves were present, wolves never arrived first, were second to arrive twice, third to arrive four times, and last to arrive once. Of six carcasses where grizzly bears were present, a bear was the first arrival once, second arrival twice, third arrival once, fourth arrival once, and fifth arrival once. Without a doubt ravens are probably the animals with the highest probability of arriving first at a carcass. However, they may not feed at all on the carcass until a larger animal has arrived. This situation has yet to be analyzed.

A graphic representation of what occurs at a carcass will be presented in diagrams for several selected carcasses. All of the information for these diagrams has not been analyzed as yet. When they are completed they will show, of the total time a carcass was watched, percentage of time that no activity occurred, the percentage of time that visibility was obscured, the percentage of time a particular species was present, and the latter will be broken down into percentage of the time present that the animal was engaged in various activities.

In order to help answer the question "What is the change in activity patterns of different species during the days that a carcass is present?" graphs will be drawn for some of the species at some of the carcasses. Some interesting patterns have turned up from analyzing the data according to major activity patterns (feeding, moving, resting) during different times of the day. The total actual activity time and frequency of consecutive periods of activity of varying lengths will be given in the final report.

Much analysis is yet to be done on the question of behavior other than major activities such as aggressiveness, caching, scraping, and others. Caching is the only one of these behavior patterns that has been treated in depth so far. Only ravens and wolves cached meat. I watched ravens make caches 881 times during 1972. Of this number, 67.8% were cached away from the carcass and 32.2% were cached near the carcass. During the time ravens were caching, they made an average of 3.85 caches in a 5-minute period; an average of 1.21 caches per 5-minute period were made during the total feeding time. Wolves were watched caching meat only 25 times, 96.0% away from the carcass and 4.0% near the carcass.

Of the time they were caching, wolves made 1.19 caches per 5-minute period; only 0.11 caches were made per 5-minute period during the total feeding time. On the average ravens made 3.2 times as many caches per 5-minute period of caching activity as wolves and 11.0 times as many caches per 5-minute period of feeding activity as wolves and 3.2 times as much time feeding as wolves.

Some of the questions which remain to be answered deal with the hierarchy of animals at a carcass, length of time a carcass will last, the importance of scavenging to the various species in terms of the meat they obtain, etc.

# # #

WILDLIFE DISTURBANCE ALONG MCKINLEY PARK ROAD

INVESTIGATOR: Diane Tracy
University of Alaska

SUMMARY OF PROGRESS: In general one still sees a large amount of wildlife from McKinley Park Road. The average observations for each of the eight-hour bus trips include 5.8 moose (*Alces alces*), 19.6 caribou (*Rangifer tarandus*), 34.3 sheep (*Ovis dalli*), 6.8 grizzly bears (*Ursus arctos*), and 2.1 foxes (*Vulpes fulva*). Most individuals of the above species found within 5 m of the road gave some reaction to the bus, but 26-44% (depending on species) showed no visible reaction when 6-30 m from the road. Some foxes become beggars and were attracted to the buses and people. Great care must be taken in interpreting these figures. Nothing is known of the physiological effects road disturbances may have on the different species and different individuals. Also the past history of the individuals is unknown. Some individuals of all the five species were noted which appeared to be thoroughly habituated to road-type disturbances, at least as long as the people did not move off the road. Undoubtedly, individuals that frequent the road area will have differing reactions from those which are only occasionally exposed to road disturbances. Variations in temperament within some species may affect which individuals are seen along the road and how they react. More sensitive animals may stay away, while those near the road show little response to disturbance.

Computer programs have been written to help analyze the bus and pickup observations in several different ways. However, analysis has not proceeded to the point where well-founded and well-stated conclusions can be made, particularly because of the many variables which must first be considered.

The study plot data are inconclusive as far as disturbance effects are concerned, chiefly because of the many possible variables and the small sample size. The best use for these data may prove to be serving as a baseline, having several defined areas with detailed, systematic notes on wildlife use, from which to determine future changes.

Intensive behavior observations on certain individuals were emphasized during the summer of 1974. Most data analysis and final writing will occur during the fall and winter of 1974, after the data collecting for the summer is complete.

# # #

PRODUCTION ECOLOGY OF WILLOW (*SALIX* SPP.)

INVESTIGATOR: John Bryant
University of Alaska

SUMMARY OF PROGRESS: Considerable time was spent planning the sampling approach, laying out study areas, and starting field measurements. The unit was unable to commit an assistantship prior to late October because of contract delays and the investigator had to accept employment for the winter. The project has been inactive; its future is questionable at this point.

# # #

MOUNT RAINIER NATIONAL PARK

ELK RANGE CONDITION AND FOOD HABITS

MORA-N-6a

INVESTIGATORS: National Park Service Personnel

SUMMARY OF PROGRESS: No work accomplished this year.

# # #

ELK MIGRATION

MORA-N-3a

INVESTIGATORS: National Park Service Personnel

SUMMARY OF PROGRESS: Twenty-six elk have been trapped during the past year, tagged, and released. Two died in traps. Heavy snows and late spring have slowed the number of observations of tagged animals. No tags have been recovered this year from hunter kills.

# # #

STUDIES ON THE EFFECTS OF ELK ON ECOSYSTEMS WITHIN MOUNT RAINIER NATIONAL PARK

INVESTIGATOR: Charles H. Driver
University of Washington

SUMMARY OF PROGRESS: Research has continued on the project through a second field season. Progress has been made on documenting the status of the elk populations using the subalpine meadows of Mount Rainier National Park as summer range. Special efforts have been made to collect data on the detrimental effects of elk use within the study areas.

As a major part of developing alternatives to the practical management of these elk populations, concerted efforts were made this season to monitor recreation hunting pressures and harvest efficiencies in areas surrounding the park. This approach should be continued to serve as a tool of herd management.

A "life table" is to be constructed from the results of the above efforts. Such a document should serve as an overall monitoring approach to elk herds utilizing Mount Rainier.

# # #

ELK INVENTORY

MORA-N-7a

INVESTIGATORS: National Park Service Personnel

SUMMARY OF PROGRESS: Pellet plots were read during September and October; some were read more than once. Data indicates that elk use in most areas where pellet transects are located has increased markedly in the past 2 years.

# # #

SUMMIT FIRN CAVE RESEARCH

INVESTIGATORS:
Eugene P. Kiver)
Willima K. Steele) Eastern Washington State College

SUMMARY OF PROGRESS: The summit ice caves have been 95% explored and 80% are mapped. Over 2 km of cave passages, including two large grottos, exist in the deeper areas of the two summit craters. A small lake about 40 m long occurs in the west crater.

The caves have been observed on a yearly basis since 1970 by competent observers to see if any major changes have occurred. Thermal changes in the crater area will first affect the summit caves and should act as an "early warning" system if the volcano should become active again. The deeper grotto areas are enlarging by about one meter a year, due to small heat increases in deeper areas of the crater.

A climb is anticipated for August 1975, to check any new changes in the crater ice caves.

# # #

TERRESTRIAL SNAILS OF THE CASCADE MOUNTAIN RANGE

INVESTIGATOR:
Branley A. Branson
Eastern Kentucky University, Richmond

SUMMARY OF PROGRESS: Thus far, I have completed collections from that area, and I am now analyzing the specimens and data.

THE DRAGONFLIES OF THE PACIFIC STATES

INVESTIGATOR: Dennis R. Paulson
University of Washington

SUMMARY OF PROGRESS: Dragonflies were collected and observed around the Sunrise Lake area during the fall of 1974. At that time, and subsequently, this area furnished the highest-elevation records of dragonflies in this state. A total of nine species was found, of which perhaps only two (*Aeshna palmata, Somatochlora albicincta*) are resident. Both of these are quite common, and other species were only found sporadically, perhaps blown up from lower elevations.

# # #

THE BEHAVIOR AND ECOLOGY OF THE HOARY MARMOT

INVESTIGATOR: David P. Barash
University of Washington

SUMMARY OF PROGRESS: The results thus far have been quite successful and encouraging insofar as future efforts are concerned. The marmots resident in Berkeley Park have proved quite appropriate for study and have revealed several fascinating leads--chief among these being the role of ecological factors in modifying paternal behavior, with implications for long-term population regulation. A manuscript detailing these findings has been submitted to *J. Mammal.* along with a shorter manuscript describing prehibernation behavior. I am hoping to continue this basic data-gathering study next year and then to seek further funding in order to pursue long-term studies of population ecology in this species.

# # #

CHARACTERISTICS OF ALPINE GLACIER TILLS

INVESTIGATOR: Hugh H. Mills
University of Washington

SUMMARY OF PROGRESS: The work done on Mount Rainier National Park was part of a Ph.D. dissertation on the deposits of mountain glaciers. Work was primarily on the Nisqually and Paradise glaciers, with lesser amounts of work being done on the Cowlitz, Emmons, Winthrop, and Carbon glaciers. Characteristics investigated included the size distribution of the depostis (i.e., the relative amounts of course and fine particles), shape and orientation of the stones in the deposits, angles of moraine slopes, and compactness of the deposits. The results have been compared with those from studies of glaciers which lie on different types of bedrock and also with deposits of continental ice sheets. The tills of the larger Rainier glaciers tend to be somewhat coarser than tills of glaciers in different locations.

# # #

(A) WASHINGTON STATE SEISMICITY
(B) MOUNT RAINIER ACTIVITY, VOLCANIC, TECTONIC, AND ICE RELATED

INVESTIGATORS:
Robert Crosson)
Stephen Malone)
Norman Rasmussen) University of Washington
Stewart Smith)

SUMMARY OF PROGRESS: Mount Fremont and Longmire stations will continue to gather earthquake data for both studies. "Stranger" events on Mount Rainier appear to be ice related. We are proceeding as planned and will continue to investigate and refine our findings.

# # #

MAMMALIAN SPECIES DIVERSITY: AN APPROACH TO THE RESOURCES BASIC INVENTORY
MORA-N-28

INVESTIGATORS:
A. R. Weisbrod, USNPS Cooperative Park Studies Unit
John A. Dragavon, University of Washington

SUMMARY OF PROGRESS: Investigation in the field began on 15 July and lasted for 10 weeks. Several additional weekends were spent afield after the beginning of the academic year and before the high country became snowed in. The initial field work concentrated on identifying and locating several permanent study plots established by earlier investigators. These plots were then sampled correlating mammal diversity with vegetative characteristics. Similar areas outside of the park, located in both Snoqualimie and Gifford Pinchot NFs were sampled for comparison to data obtained from the park.

Bibliographic work was undertaken at the park library and is currently being pursued at the University of Washington Library. Several hundred references pertinent to all aspects of the park and the mountain have been recorded. Biological data obtained from the field work are being analyzed. Further museum and library work is anticipated for the early months of 1975. It seems likely that a limited field season may be necessary prior to proposed completion of the project in the fall of 1975.

Certain logistic problems caused by heavy lingering snow of 1974 and mileage restrictions on GSA vehicles should be avoided in the coming field season if snow pack is less or water content lower and non-federal vehicles are used for field work.

# # #

NORTH CASCADES NATIONAL PARK

HUMAN IMPACT AND GROUNDCOVER AT BACKCOUNTRY VISITOR-USE AREAS
NOCA-N-41

INVESTIGATOR: C. Robert Wasem
National Park Service

SUMMARY OF PROGRESS: A modification of the three-step method for measuring trend in range condition (Parker 1951) was used to indicate the percentage cover of various ground cover components in 27 backcountry camps during the summer of 1974. Data obtained was used to analyze the desirable and undesirable aspects of ground cover in each campsite, and to provide both an observation and a quantitative means of measuring change in the ground cover of the camps and in some instances in the size of the camp area over a period of time. A progress report (Mullen and Wasem 1974) was issued on 10 December 1974. It is planned to continue the project in 1975 with some modifications in measurement and photographic techniques.

Mullen, K. D. and C. R. Wasem. 1974. Ground cover studies at backcountry human impact areas during 1974 summer. National Park Service Misc. Research Paper NCT-2. 11 p.

Parker, K. W. 1951. A method for measuring trend in range condition on National Forest ranges. USDA Forest Service Administrative Studies (condition and trend) Report. 26 p.

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RESERVOIR ECOLOGY (RESERVOIR ECOSYSTEMS AND SPORT FISHERIES)
NOCA-N-24

INVESTIGATOR: C. Robert Wasem
National Park Service

SUMMARY OF PROGRESS: This project is not scheduled for official funding until 1 July 1976. However, some preliminary studies were in progress in 1974 and are summarized as follows:

1. A progress report on chemical and physical limnology of Thunder Arm of 364-ha Diablo Lake is in preparation. Field data was collected between April and late November 1972 and May and late November 1973.

2. Sanitary water quality of Gorge Lake, Diablo Lake, and Lake Chelan was determined by membrane filtration techniques to isolate coliform bacteria. The majority of waters were sampled several times between April and late August. Most sample points yielded negative results or insignificant counts of coliforms. However, several stations adjacent to human-use areas displayed significant high counts on occasion. Results of coliform testing for 1974 will be released later this winter in the form of a progress report. Sampling will continue in 1975.

3. Fish fauna and limnology studies continued at the head of Lake Chelan. Field work was carried out in June 1974 and briefly summarized as follows:

   a. Physical and chemical limnology was studied at five mid-lake stations from Weaver Point near the Stehekin River inlet to a point off Riddle Creek near the National

Recreation Area boundary. Measurements consisted of dissolved oxygen, hydrogen-ion concentration (pH), specific conductance, total hardness, Ca hardness, Secchi disc visibility, turbidity, HCO_3 alkalinity, and temperature profiles to the 30 m depth. Results appear in a progress report (Misc. Research Paper NCA-8) released in November 1974.

b. Fish fauna studies by use of four overnight gill net sets were continued from June 1973. In 1974 the total catch was 64 fish captured with a total of 70.4 hours of net-sets for a mean catch rate of 0.909 fish per hour of net set and 0.032 fish per hour per 100 ft^2 of net set. Netting efforts are designed to study species composition of the Lake Chelan fauna rather than to attempt to assess species population sizes and distribution. Seven species representing four families comprised the 1974 catch.

Species	No.	Percent
Rainbow trout (*Salmo gairdneri*)	1	1.56
Kokanee salmon (*Oncorhynchus nerka*)	4	6.25
Burbot (*Lota lota*)	1	1.56
Peamouth (*Mylocheilus caurinus*)	6	9.37
Northern squawfish (*Ptychocheilus oregonensis*)	11	17.19
Largescale sucker (*Catostomus macrocheilus*)	23	35.94
Longnose sucker (*Catostomus catostomus*)	18	28.12

More detailed results including fish sizes and condition factors appear in a progress report (Misc. Research Paper NCA-8) released in November 1974. This study will continue in June 1975 with more emphasis on collection of sculpins, stickleback, and redside shiner to confirm their presence in the aquatic ecosystem.

c. Spawning kokanee salmon collections continued in Company Creek on 5-7 November 1974. Total lengths, fork lengths, weights, and fecundity were checked on 255 fish (187 males and 68 females). The average size of both sexes was considerably less than in 1973. Results of kokanee studies from 1971 through 1974 are given in two progress reports--Miscellaneous Research Paper NCA-7 released in June 1974, and an updated report in preparation.

# # #

EFFECTS OF FISH INTRODUCTIONS UPON NATURALLY FISHLESS MONTANE LAKES

NOCA-N-12

INVESTIGATOR: C. Robert Wasem
National Park Service

SUMMARY OF PROGRESS: The 4.92-ha unnamed lake and small unnamed 0.29-ha pond below it on the north side of 2418 m high McAlester Mountain (Lake Chelan NRA) were visited on 4-6 September 1974 to determine their suitability for the study. It was believed the lakes would be barren of fish life and thus provide an ideal study area. This was not to be as gill nets and angling produced 10 rainbow trout (*Salmo gairdneri*) from this oligotrophic subalpine lake. The 10 fish averaged 291 mm (11.33 inches) in fork length and 304 grams (10.71 ounces) in weight with the largest fish being 341 mm (13.3 inches) in fork length. The lake is populated by a well-established but sparse population of trout and is not suitable for the study. The investigator will continue searching for a study area.

# # #

MOUNTAIN STREAM ECOLOGY
NOCA-N-23

INVESTIGATOR: C. Robert Wasem
National Park Service

SUMMARY OF PROGRESS: 1. Basic water quality was determined on 61 occasions in 47 streams in 1974. Measurements consisted of pH, alkalinity, specific conductance, total hardness, Ca hardness, total dissolved ionizable solids, dissolved oxygen, temperature, and turbidity. Total coliform bacteria and total iron and ferrous iron also were measured in several streams. Stream width, depth, velocity, and discharge were measured in Company Creek, Riddle Creek, Bridal Veil Creek, Canyon Creek, and Castle Creek.

2. Resident stream fishes were collected by angling (no electrofisher available) from Company Creek, Chilliwack River, Indian Creek, Deer Creek, Pyramid Creek, Sulphide Creek, Babcock Creek, Lake Creek, Baker River beaver ponds, State Creek, Bridge Creek, Goodell Creek, Damnation Creek, and Thornton Creek. Captured fish were measured for length and weight and scale samples and stomachs taken for later age-growth and food habits analysis.

Condition factors (K-FL) were also determined for all sampled fish.

# # #

MOUNTAIN LAKE ECOLOGY (MOUNTAIN LAKE ECOSYSTEM SURVEY)
NOCA-N-22

INVESTIGATOR: C. Robert Wasem
National Park Service

SUMMARY OF PROGRESS: The principal investigator, assisted much of the time by a seasonal biologist, made nine trips to study natural lakes of the North Cascades complex. Eleven individual lakes were reached. Hozomeen Lake was studied in June and again in mid-September. Stout Lake was reached by helicopter and Thunder Lake by road--all other lakes were reached by trail and backpacking. Short progress reports for immediate use by management and interpretation will be prepared for each lake. Lakes visited and study dates follow:

Hozomeen Lake	6/19-21/74
Ridley Lake	6/20-21/74
Panther Potholes	7/22-23/74
Dagger Lake	8/6-8/74
unnamed tarns at Twisp Pass	8/8/74
Stout Lake	8/21-23/74
two unnamed lakes on McAlester Mountain	9/5-6/74
Hozomeen Lake	9/17-18/74
Thunder Lake	11/13-14/74

Progress on this study is slow due to an extremely short ice-free season, the inaccessibility of most study lakes, and the large number of natural lakes in the complex (over 235 lakes, ponds, and tarns). It is recommended that the research be continued for at least 3 more years if the more important lakes are all to be studied.

# # #

STABILIZATION OF EXPOSED BED OF LAKE CHELAN WITH NATIVE PLANTS

NOCA-N-42

INVESTIGATOR: C. Robert Wasem
National Park Service

SUMMARY OF PROGRESS: Four-square-meter plots were established on the wind-swept drawdown bed of Lake Chelan just northwest of Stehekin on 7 and 8 May. The only native plant of any importance is *Plagiobothrys scouleri* var. *penicillatus* of the family Boraginaceae which helps stabilize wind-blown sand and silt in limited moist areas. On three of the plots the number of plants and plant diameters in millimeters were recorded. On plot number 4, 18 plants dug in the area of plot number 1 were transplanted and watered to check survival and therefore feasibility of transplants to other denuded areas of the exposed lakebed. All plots were photographed from fixed photo points.

The plots will be checked again in late April or early May 1975 to determine survival and new growth after many months of water inundation and exposure to cold, winter winds.

# # #

REJUVINATION OF WOODY BROWSE PLANTS BY CUTTING AND PRESCRIBED BURNING ON WINTER DEER RANGE

NOCA-N-43

INVESTIGATORS: C. Robert Wasem, National Park Service
Jack Adkins, Washington Game Department

SUMMARY OF PROGRESS: Mule deer and blacktail deer winter range along Ross Lake was investigated in October 1973 and July 1974 for the purpose of locating a suitable study site. A study area just south of Lightning Creek and above the foot trail was choosen in July 1974. During the week of 16-20 September 1974, the investigators, with additional help from the National Park Service and State Game Department, established one treatment plot and two control plots. The treatment plot is 30 X 45 m (1350 m^2) and will consist of six sub-plots 15 m^2 (225 m^2), three of which will be cut, stockpiled, and burned and three of which will be cut only. All shrubs and small lodgepole pine on the treatment plot were cut in September but will not be burned until April or May 1975.

The two control plots lie on either side of the treatment plot but not directly adjacent. Control plots are 15 m^2 (225 m^2) and contain a number of tagged sample shrubs on which annual leader development will be measured each autumn and compared with growth of cut and burned sample plants on the treatment plot.

Response of sample shrubs on the treatment plot will be monitored for at least 5 years and compared with annual growth of sample plants of the same species located on the control plots.

# # #

HEPIALID MOTHS AND HIGH ALTITUDE BUTTERFLIES

INVESTIGATOR: Norman B. Tindale
South Australian Museum, Adelaide, S. Australia

SUMMARY OF PROGRESS: Laboratory studies were continued during the year but absence in Canberra, Australia, prevented field work in the area. One new *Hepialus* was detected in Arizona and is being studied. Indications are being strengthened that some *Hepialus* species may be destructive of high altitude tussock grasses. The companion study of alpine butterflies enables best research use to be made of the time.

# # #

FOREST FIRE ECOLOGY IN NORTH CASCADES; CASCADE PASS REVEGETATION; AND PLANT ECOLOGY INVESTIGATION (BIG BEAVER VALLEY)

INVESTIGATORS: Joseph W. Miller
Margaret M. Miller

SUMMARY OF PROGRESS: During 1974 we completed marking with plastic stakes the 103, 10 m^2 permanent plots on the Silver Creek and Thunder Creek burn sites. We also again recorded the coverage of vegetative species according to the Braun-Blanquet species magnitude scale and vitality index. The results of the current season's recovery were compared with the 1971 and 1972 findings and incorporated into a paper for presentation at the Fifteenth Tall Timbers Fire Ecology Conference in Portland, Oregon, in October. A copy of the formalized paper, which will be published in the Conference Proceedings by the Tall Timbers Research Station, has already been furnished the National Park Service.

In August and September we visited Cascade Pass for the purpose of continuing evaluation of previous plantings and the planting of new material grown at our home since the 1973 season. With the aid of four other volunteers, we carried 17 apple boxes containing 167 plastic trays of native plants of nine different species from the parking lot to the pass. At the time of our visits there had been 100% survival of all plantings made in 1973. A detailed report of our 1974 findings and activities is in preparation.

In August we spent 3 days in Big Beaver Valley conducting an investigation into the existence of east-side vegetative influences in this west-side valley. The study consisted of establishing 20, 10 m^2 plots in Douglas fir climax stands and Douglas fir-lodgepole pine stands and examining the ecological relationships of the vascular plants therein. The completed data have been submitted to the Federal Power Commission in connection with the High Ross Dam hearings.

# # #

ROSS LAKE STUDIES

INVESTIGATORS: R. L. Burgner)
William Parr) University of Washington, Seattle

SUMMARY OF PROGRESS: Food supply of the fish and limnological conditions in the reservoir were monitored--zooplankton and benthic samplings were conducted periodically, phytoplankton standing crop (chlorophyll a) was measured approximately every 6 weeks, primary production (^{14}C method) was measured 3 times between 6 August and 23 October.

Further information on timing and location of trout spawning and relative importance of spawning tributaries above and below full pool elevation of the proposed reservoir was obtained.

We continued studies of survival of fertilized trout eggs transferred from streams in which spawning areas would be reduced by the higher proposed reservoir to a stream in which spawning areas would be increased by flooding of a migration barrier.

Creel census and fish sampling, tagging, and recovery programs were continued in 1974 to measure the size of the fish population in Ross Lake and the Canadian Skagit River and to determine fish size, sex, and maturity and age composition of the population.

Limnological conditions in Diablo and Gorge lakes were monitored with water chemistry measurements and sampling of phytoplankton (chlorophyll a) zooplankton and benthos. Fish were sampled scientifically and from anglers creels for length and weight.

Studies of the effects of forecasted temperature changes in the Skagit River below Newhalem (resulting from increased levels of Ross Lake) were implemented by the institute in 1974. The objectives are to determine how development of eggs and fry of salmon and steelhead trout, their condition at time of emergence from the gravel, and the food supply of juvenile salmonids would be affected. Bi-weekly sampling of fry at three stations on the Skagit River below Newhalem and at one station in the Cascade and Sauk rivers was begun in early February 1974 and will be continued in 1975. Dendy samplers were used at each station to collect samples of benthos for comparison with stomach contents of juvenile salmonids.

Generally, dissolved oxygen concentration is near saturation and frequently above saturation throughout Ross Reservoir except within a few meters of the bottom during summer-fall thermal stratification.

Sudden spring or summer phytoplankton blooms apparently do not occur in Ross Reservoir. Standing crop of primary producers gradually builds up from late spring to late summer. Primary production and standing crop of phytoplankton probably are limited by the relatively constant low level of nutrients, particularly phosphate. Zooplankton abundance follows seasonal trend similar to that of the phytoplankton, and the density of both is relatively low and characteristic of a highly oligotrophic lake.

Because of colder stream temperatures and later spawning in 1974, emergence of fry from the gravel and timing of downstream migration to the lake was about 2 weeks later than in 1973. Fry abundance also appeared to be substantially less in 1974. To establish the relative importance of the spawning areas utilized with the reservoir at present operating levels further studies of fry production in each spawning stream are planned for 1975.

A significant proportion of trout fry are produced in Dry and Roland creeks, mostly below the elevation of the proposed reservoir (525.8 m). Our research on artificial fertilization and transfer of trout eggs from these areas to gravels of other streams above the 525.8-m elevation has shown that the entire trout fry production of each of these streams could be replaced inexpensively by this means.

The annual recreational catch since 1971 has amounted to about 41,000 fish. The legal-sized trout population in the reservoir and its tributaries has been estimated by tagging and recovery. Estimates for 1971-74 show that the population has stabilized at approximately 200,000 fish.

The age composition of angler-caught and scientifically sampled rainbow trout along with tag recovery data were used to estimate survival and mortality rates for the rainbow trout in the reservoir and Canadian Skagit River. The data indicate a nearly uniform fishing mortality (about 20%) on rainbow trout above "legal" size that is independent of age, and an increase in natural mortality with age beyond age 2 (undoubtedly due to post-spawning mortality). Annual natural mortality for age 2 fish was approximately 41%, age 3 fish 72%, and age 4 fish 79%. No trout above age 5 were observed in the reservoir population.

Preliminary results of studies on Diablo and Gorge reservoirs show that Diablo has a slightly higher standing crop of phytoplankton in the euphotic zone than in Ross Lake. Standing crops of zooplankton and benthos are higher in Diablo than in Ross. Gorge Reservoir has a high flushing rate. Standing crops of phytoplankton, zooplankton, and benthos are the lowest of the three reservoirs.

Results of research on the Skagit are presently under analysis and are not completed.

Plans for continuation of research will focus on studies of the Skagit River below Newhalem relative to effects of forecasted temperature changes in the stream biota. Observations of fry stranding on gravel bars resulting from river fluctuations caused by upstream reservoir operation will be conducted.

Salmon and steelhead trout escapement data from Washington Department of Fisheries records will be analyzed for patterns that may be related to river conditions during juvenile stream residence.

Aerial surveys are planned for fall 1975 to enumerate spawning escapement in spawning areas above Copper Creek (site of a proposed dam for a reregulation reservoir relative to those remaining if the Copper Creek Dam is constructed). Shocking and fykenetting for samples of stream resident fish in the Skagit River and its tributaries above the Copper Creek site will also be conducted.

Studies at Ross Reservoir will focus on determination of relative importance of stream spawning areas to be inundated if the height of Ross Dam is increased as proposed and to establish whether this varies from year to year. Assessment of stream resident populations in the tributary streams will be done in stream reaches which would become accessible to fish from Ross Lake if the dam is raised.

# # #

OLYMPIC NATIONAL PARK

MANAGEMENT STUDIES OF HUMAN IMPACT UPON THE ECOSYSTEMS OF OLYMPIC NATIONAL PARK

OLYM-N-16

INVESTIGATOR: Bruce B. Moorhead

SUMMARY OF PROGRESS: Human trampling impact upon low vegetation was examined and measured at 325 campsites in 27 camping locations in the backcountry of the park. Campsite maps were surveyed at 19 locations to enable long-term monitoring of campsite changes and use patterns. Impact severity is being evaluated from the abundance of campsites, their contiguous social trails, and measurable plant cover changes at sites. Permanent study plots were installed at campsites using a radial design consisting of eight linear intercepts, each 10 m in length, radiating in eight directions from the center of a trampled fire-ring or tent "pad." Vegetation, or its absence, was recorded in centimeter intervals along each transect. One hundred nineteen of these plots with 952 intercept lines were read.

In 1975, a computer card format will be devised to record in the field extensively surveyed information, enabling more comprehensive and rapid analyses of diverse components affecting impact and use patterns. For example, indexes of creel success and productivity potentials for high lake fish populations will be sampled and integrated with impact assessments and other data obtained at camping locations and component sites. Site restoration attempts, incluidng vegetation transplanting, will be initiated and experimented with at Lake Constance, Flapjack Lakes, and continued at Deer Lake. Soil compaction and forest litter profiles will be sampled at the above areas and adjoining control locations. An attempt will be made, moreover, to locate suitably unaltered (in the sense of "unused") high lakes as control study locations. Optimal-use guidelines in preparation will treat priority problems evident at locations in a timely and specific manner, while attempting to provide sound long-term ecological bases for use management.

# # #

ECOLOGY AND MANAGEMENT OF NON-NATIVE MOUNTAIN GOATS IN OLYMPIC NATIONAL PARK

OLYM-N-15

INVESTIGATOR: Bruce B. Moorhead

SUMMARY OF PROGRESS: Mountain goat census continued in the 4th year of a 6-year project to investigate the population characteristics of this nonnative mammal in the Olympic Mountains. Two hundred eighteen goat observations on Mount Angeles were analyzed for population structure and distribution. 100-125 goats are not estimated to occur on this mountain, the largest segment of an overall population estimate of 500+ (90% of which occurs in the national park). The over-winter mortality of 1973 kids on Mount Angeles was estimated to be 84%. Kid-female ratios in 1974 were 68%. Standard body measurements were obtained on 11 goats that were captured, marked and released as reference animals on Mount Angeles. Subsequent resightings of 18 individuals marked since 1972 has confirmed seasonal movement patterns on Mount Angeles and provided an added means of validating population estimates.

A paper entitled *Introduction and dispersal of nonnative mountain goats in the Olympic Mountains, Washington* was given at the Wildlife Society meeting in April at Edmonton, Alberta. A manuscript of the same title is being readied for submission to a journal.

# # #

VEGETATION DYNAMICS AND HUMAN TRAMPLING

INVESTIGATOR: Edward G. Schreiner
University of Washington

SUMMARY OF PROGRESS: A Masters Thesis was completed in May 1974. *Vegetation dynamics and human trampling of three subalpine communities of Olympic National Park.*

A project such as this is really never finished in the sense that problems are not resolved completely. The nature of ecosystems as well as human use is continually changing.

We are at present in need of setting up measurement and monitoring systems of changes as they take place over the next few years. Management effectiveness would be greatly enhanced by such a system. To manage an area without provisions for change and testing of management policies is to deny the complexity of ecosystems.

A synthesized version of the above thesis is to be published through the office of the Regional Chief Scientist and thus will not be included here.

# # #

ECOLOGY OF THE OLYMPIC MARMOT

INVESTIGATORS: Richard W. Fonda
William A. Wood

SUMMARY OF PROGRESS: A manuscript is being prepared and will be submitted to a journal for publication sometime in the future. The important findings have been summarized in previous reports and in the thesis on deposit in the park. We probably will need to do some more field work in summer 1975 on inventorying colonies and quantifying vegetation-burrow relationships.

# # #

FEEDING HABITS OF *MICROTUS OREGONENSIS* AND *M. LONGICAUDUS* IN OLYMPIC NATIONAL PARK

INVESTIGATORS: Richard W. Fonda
Mark Sheehan

SUMMARY OF PROGRESS: Stomach contents of the voles are being examined microscopically and a synthesis of their food during stages of the summer growing season is being prepared. Sheehan's thesis should be finished sometime in summer 1976, and available near the beginning of fall.

This work attempts to understand the niche and habitat separation that the voles exhibit on Hurricane Ridge. So far there is a clear separation of the two species on Hurricane Ridge, with *M. oregonensis* occupying the higher elevation communities dominated by sedges and grasses, and *M. longicaudus* in avalanche chutes with woody shrubs (willow, alder) and semi-aquatic forbs.

# # #

ECOLOGY OF ALPINE TIMBERLINE IN OLYMPIC NATIONAL PARK

OLYM-N-18

INVESTIGATOR: Richard W. Fonda

SUMMARY OF PROGRESS: This year a paper on "The influence of subalpine snowbanks on vegetation pattern, production, and phenology" was accepted by *Bull. Torrey Bot. Club*.

It will appear early in 1975 in volume 102 of the bulletin.

Significant findings to date were submitted with last year's report. Next summer I will be focusing on water relations of the trees at timberline through the course of the growing season, and trying to relate water balance to growth. We will probably monitor microenvironment once again at Eagle Point.

# # #

BLUE GLACIER PROJECT
OLYM-N-7

INVESTIGATOR: Edward R. LaChapelle
University of Washington

SUMMARY OF PROGRESS: The Blue Glacier Station was staffed from mid-June until early September during 1974. Field work was under the supervision of Ms. Patti Olson, who was carrying out glacier research directed toward a Master's Degree in Geology. Her work involved a resurvey of the surface configuration and motion pattern of the lower Blue Glacier for comparison with a similar survey done in 1958 by Meier. This comparison is expected to provide valuable information on the effects of strong positive mass balances resulting from recent heavy winter snowfalls. Survey results have not yet been calculated, so the exact nature of the surface changes cannot yet be specified.

The basic climate and mass balance observations were continued again as in past summers. This was a year of unusually heavy snowfall. Preliminary calculations indicate a strongly positive mass balance for the Blue Glacier this year. This is reflected further by a continued trend toward thickening of the ice near the terminus, a trend which was first noticed two years ago.

In August, the Blue Glacier facility provided an excellent site to carry out a series of tests on the strength properties of hard, high-density snow of the kind characteristic of summer fern in this climate. These tests were part of a research program on avalanche control methods for the Washington and Colorado highway departments. Newly-designed devices (non-explosive) for breaking hard avalanche slabs were tested for operation under maximum load conditions on the Blue Glacier firn. Thanks to the opportunity for efficient field work at the Blue Glacier station, we were able to complete these tests very quickly and proceed to operational designs which could be installed in the Cascades and Colorado rockies for test during the winter of 1974-75. A total of 18 people participated in the project this summer, most of them for short periods of time. Typically two of three people were at the station at any given time, except during the snow tests in August when five additional researchers journied up the Hoh Trail. All were students except for two faculty and one staff engineer, and all persons worked on a volunteer basis. There were a total of six aircraft trips to the glacier. Two were flights by Beaver from Seattle, one in June and one in July. Four were by helicopter from Forks. Three of these were in August to transport test equipment in and out from the glacier. One was for final evacuation of equipment in September.

# # #

THE NATURAL HISTORY OF THE INTERTIDAL ZONE ALONG THE COASTAL SECTION OF OLYMPIC NATIONAL PARK

OLYM-N-23

INVESTIGATOR: Steven Forrest Blau
University of Washington, Seattle

SUMMARY OF PROGRESS: Field observations of the intertidal algal and invertebrate zonation were made by walking from the Ozette River to Kalaloch beach. These observations were made from 23 June to 1 September 1974, including a 5-day trip to Tatoosh Island. Observations of birds and mammals interacting with the tidal zone were also noted, including bald eagles, shorebirds, river otters, harbor seals, etc.

Much of the above information will be used in writing my interpretive Master's Thesis (University of Washington) on the natural history of this intertidal zone, planned to be completed by June 1975. It would be wise for ONP to obtain a copy of this thesis when it is finished.

It was originally planned to extract information from this thesis to produce two interpretive booklets: (1) a seashore activities booklet for children, including drawings of common marine life through research funds provided by Donald Field, P.N.R., NPS Chief Scientific Researcher; and (2) an adults' booklet on the common intertidal life found along ONP coastal section, to be sponsored by the now defunct Olympic Natural History Association with whom I was working closely with David Huntzinger.

I still have strong interest in completing these interpretive seashore booklets. At the moment both of these booklets are in doubt of completion due to lack of funding from previous commitments (see above paragraph). I am now seeking funding from James Richardson, Interpretive Management Specialist PNR, for the childrens' booklet and am in contact with Robert Clark of the Pacific Northwest Park Association about my previous commitment to complete an adults' seashore interpretive booklet.

RECOMMENDATIONS: (1) Olympic National Park might consider the funding of the childrens' booklet if the regional office is not able to. (2) Hire seasonal or full-time naturalists familiar with the local marine life for this coastal section of ONP. From summer observations, seasonal ranger-naturalists were unfamiliar with the local marine life, i.e., a girl from Florida, and misinformation about marine life was being given out at both Mora and Kalaloch ranger stations on scheduled tide pool walks, with the exception of Simon Simonian. Many interpreters feel that no interpretation is better than misinformation. (3) The addition of a seasonal ranger-naturalist to the Ozette Ranger station to conduct tide pool and forest walks for the heavily visited Cape Alava-Sandpoint areas.

# # #

FORESTS OF THE OLYMPIC MOUNTAINS

OLYM-N-18

INVESTIGATOR: Richard W. Fonda

SUMMARY OF PROGRESS: A paper on Hoh Valley vegetation, "Forest succession in relation to river terrace development in Olympic National Park, Washington," was published in *Ecology* 55:927-942.

Currently Andy Kratz, a graduate student, is about half finished with his thesis on the coastal Sitka spruce forests in the park. We expect this thesis to be finished about the first week in April and available to the park near the end of April. It should be ready sometime in 1976.

Presently work on understanding forest communities awaits another student with an interest in forest patterns. We especially need to gather information on the coastal forest of western red cedar-western hemlock. I'm hopeful that next year will bring such a student.

# # #

ECOLOGY OF *PHYLLODOCE EMPETRISFORMIS*

INVESTIGATOR: Ingrid C. Olmsted
Duke University

SUMMARY OF PROGRESS: I should like to indicate one point in particular with regard to human impact on *Phyllodoce empetrisformis:* there are no seedlings to be found in the field, reproduction seems to be profusely vegetative. With a constant trampling during the growing season in places like 7 Lakes basin, for instance, a lot of *Phyllodoce* cover can be lost and reestablishment (without human help) will be almost nil. This is a very important consideration for management of areas with heather. I shall give a more comprehensive report when I am done with the analysis of my data.

# # #

OREGON CAVES NATIONAL MONUMENT

INTERRELATIONSHIPS OF LIGHT AND GREEN PLANTS IN CAVES

ORCA-N-1A

INVESTIGATOR: James A. Blaisdell
National Park Service

SUMMARY OF PROGRESS: With the assistance of Herbert Curl, Oregon State University, the project was completed and recommendations for algae, moss, and fern control made.

A combination use of ultraviolet light where visitors are shielded from it and chemicals should be used to control unwanted cave plants. Especially good for algae is copper sulfate ($CuSO_4$), and for mosses, *Divron* (DCMU).

# # #

OZARK NATIONAL SCENIC RIVERWAYS

WATER QUALITY STUDY

INVESTIGATOR: Jim Barks
U. S. Geological Survey

SUMMARY OF PROGRESS: Objectives of this study are to: (1) document existing physical, chemical, and biological characteristics of the streams and springs in the Riverways; (2) detect and investigate areas of anomalous water quality, and (3) determine the influence of visitor-use on water quality in heavy-use areas.

A mobile laboratory was used for the collection and transportation of water samples. Comprehensive analyses were made at 24 sites to provide a synoptic view of water quality. Four key sites were selected for repetitive sampling to show variations with time, run-off, and area uses. These sites were sampled quarterly for physical chemistry, trace metals, and basic biological analyses and bi-weekly during the summer for pesticides. In August, a special study was made on the Jacks Fork below the Alley Spring Campground. Water temperature, dissolved oxygen, and bacteria were measured at 2-hour intervals for 12 consecutive hours for evaluation of influences on water quality caused by several hundred horses crossing the river. Although field determinations were made for properties which change rapidly, most samples were analyzed at specialized USGS facilities. The data have been stored in the main Water Resources Division computer file in Reston, Virginia, for later retrieval. Data collection for the 1974 calendar year was completed in December.

A final report covering all work performed during the 3-year duration of the study will be prepared by the USGS in 1975.

# # #

RIVER-USE INVESTIGATIONS

INVESTIGATOR: Leo F. Marnell
National Park Service

SUMMARY OF PROGRESS: Six time-lapse cameras were rotated among 10 locations along the Current and Jacks Fork rivers to record river traffic. The project was initiated experimentally in 1972 and has been operational along the entire riverways for the past 2 summers. Approximately 310 rolls of 8-mm film were taken between 26 May and 1 September; these recorded 3720 hours of river traffic. Observations recorded by park rangers on daily boat patrols provided supplemental information. A floater Card Survey was also instituted this season to provide additional information of float-trip patterns. Collectively these projects will provide information on the volume, composition, ownership, and distribution of river traffic during the peak season. A more advanced camera timer was used this past season effectively reducing driving mileage and night operations on the project. An electronic time-reference system is presently under development for use in 1975 to quantify the time-distribution of traffic on different sections of river.

A summary report will be prepared by 30 May 1975; however, preparation of a final report for all work accomplished during the summers 1972-75 will be deferred until after the 1975 field season.

# # #

FLOATER IMPACTS ON RIVERWAYS ENVIRONMENTS

INVESTIGATOR: Carl D. Settergren
University of Missouri

SUMMARY OF PROGRESS: Development of an ecologically sound river-use management plan at Ozark National Riverways requires consideration of changes occurring in the environment resulting from floater use. Objectives of this study are to: (1) measure and document floater impacts in areas receiving moderate to heavy use; (2) identify unique areas and natural features that are particularly sensitive to physical abuse; (3) identify sites where resource deterioration has reached the critical stage; (4) evaluate prospects for restoration during periods of nonuse; (6) recommend methods for protection and maintenance in areas receiving heavy use; and (7) recommend guidelines that will enable the National Park Service to continue monitoring floater impacts after completion of the study.

Field work conducted during the past two summers consisted of reconnaissance, selection of study sites, mapping, photo documentation, and cataloging of areas receiving floater impacts. Preliminary findings indicate that vehicular activities attending canoe floating and other types of river use are generating significant and destructive impacts. Pulltite Spring, Cave Spring, and other natural features have been heavily impacted and corrective measures will be necessary. Gravel bars appear to be relatively insensitive to floater use.

A final report for the project will be prepared this calendar year.

# # #

FLOATER SOCIOLOGICAL STUDIES:
GROUP BEHAVIOR OF CANOE FLOATERS AT OZARK NATIONAL SCENIC RIVERWAYS

INVESTIGATOR: Kenneth C. Chilman
South Illinois University

SUMMARY OF PROGRESSL A sociological study was undertaken at Ozark between June and September to probe an important aspect of canoe floating on park waters. The project involved an evaluation of floater group behavior and on-site group interactions. A combination interview and mail-questionnaire survey was administered to floaters associated with groups of 20 or more persons. Objectives of the study were: (1) to find out what factors motivate people to float with large groups; (2) to learn what advantages and disadvantages are perceived by members of large groups; (3) to assess the nature and extent of conflicts between groups and among individuals within groups, and (4) to identify behavior patterns characteristic of large group floaters.

The study is being written up as a Master's Thesis at Southern Illinois University with a projected completion date of June 1975.

# # #

WILDLIFE HABITAT MANAGEMENT: MANAGEMENT OF OPEN-FIELD HABITAT FOR WILDLIFE

INVESTIGATOR: Leo F. Marnell
National Park Service

SUMMARY OF PROGRESS: Numerous tracts adjoining the Current and Jacks Fork rivers were formerly cultivated for production of corn, milo, and legume hays. However, farming has declined due to a shift in the regional economy from subsistent agriculture to tourism and recreation. Inclusion of many fields within Ozark National Scenic Riverways also contributed to the abandonment of farming in bottom lands along the Current River. Consequently, many fields have been fallow for several years and some are on the verge of reverting back to undergrowth.

The Master Plan and Enabling legislation for OZAR and existing agreements between the National Park Service and the Missouri Conservation Department endorse the concept of wildlife habitat improvement. A program was started in 1972 to inventory the fields and recommend measures for their restoration to a useful and productive condition. Cultivated fields are beneficial to wildlife, including both game and nongame species, particularly during periods of natural food shortages and severe winters. The fields are also esthetically pleasing remnants of a past era.

Approximately 2300 acres are being administered under Agricultural Lease Permits for production of row crops (28%) and legume hays (72%). fertilizer specifications, border strips, cutting times, and various other conditions are specified in the permits to ensure that wildlife benefits are realized.

The inventory phase of the program is completed and management guidelines are presently under review. One modification made in the program this year was deemphasis of row-crop projects. The poor quality of Ozark soil, scarcity of farmers experienced in and equipped for row cropping, and numerous administrative difficulties pointed to the need for reconsideration of this aspect of the program. In many cases now, row cropping is specified as an option rather than a requirement. Greater emphasis is being placed on legume hay production in combination with wildlife food plots.

The program is approaching its maximum acreage potential.

# # #

OZARK FISHERY INVESTIGATIONS

INVESTIGATOR: Leo F. Marnell
National Park Service

SUMMARY OF PROGRESS: The National Park Service continued a summer creel survey on portions of the Current and Jacks Fork rivers in 1974. Information was obtained on angler success, catch composition, and fishermen characteristics; biological data were also collected for selected species of game fish through scale collections and length measurements. Approximately 800 boat and bank anglers were contacted by a seasonal clerk who traveled by canoe and jonboat.

The purpose of the creel survey is to provide a basis for management recommendations made to the Missouri Conservation Department. The survey will be continued at least another summer.

Problems have been mainly with field logistics due to the distances involved, navigational difficulties, and the necessity of a one-way downstream operation on some sections.

The low educational level and occasional hostile attitudes of Ozark fishermen have also created some difficulties in the gathering of data.

Scales from smallmouth bass and rockbass collected during the survey are mounted by cooperative personnal at the Missouri Conservation Department's research lab in Columbia. Scale reading is being done by the student who performed the field work. A full report summarizing the results of work accomplished during the period 1972-75 will be prepared after next season's field work. Plans for continuation of the fishery survey beyond 1975 are indefinite at this time.

# # #

TROUT STOCKING IN THE UPPER CURRENT RIVER

INVESTIGATOR: Leo F. Marnell
Missouri Conservation Department

SUMMARY OF PROGRESS: During the past year the Missouri Conservation Department released approximately 1800 catchable-sized rainbow trout into the Upper Current River at access points above Akers Ferry. Plantings were made over a period of several months beginning in the spring. As in most Missouri streams, trout do not reproduce in the Current River; thus, the program is a "put and take" proposition. Its purpose is to provide trout fishing for a select group of Missouri sportsmen in a quasi-natural setting.

Trout for this program are raised up to about 10 inches in length at the Montauk State Fish Hatchery at the headwaters of the Current River. Production costs averaged about $0.75 per pound of trout.

No major change in the stocking allotment is anticipated for 1975, unless a proposed "fish for fun" program is implemented. This program would allow anglers to keep one trout 16 inches or over in length per day. The program has been jointly recommended by the National Park Service and the Missouri Conservation Department, but administrative complications have prevented implementation. It appears unlikely that land ownership problems connected with this proposal will be resolved this coming year; thus further delays in the fish-for-fun program are imminent.

# # #

FLOOD DAMAGE TO ALLEY SPRING DEVELOPED AREA

INVESTIGATORS: Leo F. Marnell)
Roy N. Smith) National Park Service

SUMMARY OF PROGRESS: Recent channel changes in the Jacks Fork River above and below the Highway 106 bridge have allowed flood waters to invade the Alley Spring developed area and cause extensive damage to property and facilities maintained by the National Park Service. Upstream from the bridge the channel has cut to the west and eroded into a major campground and day-use area. Rapid erosion is taking place and tons of loose gravel have been spread over campsites. Below the highway bridge flood waters have cut several erosion gullies into a major day-use area and transported large quantities of gravel across roads and picnic sites. A loop of the Alley Spring branch has been invaded and gravel deposition is occurring.

The flood and erosion situation has catastrophic potential in this area because campground and day-use facilities at Alley Spring are currently undergoing renovation. A plan being formulated for corrective measures will involve selective removal of willow thickets and other vegetation obstructing the main channel. An Environmental Assessment for the proposed work is under preparation. The project will be carried out by National Park Service personnel.

# # #

PADRE ISLAND NATIONAL SEASHORE

BASELINE ECOLOGICAL STUDY OF MAMMALS ON PADRE ISLAND NATIONAL SEASHORE

INVESTIGATOR: John T. Baccus
Wiley College

SUMMARY OF PROGRESS: Field work was initiated in the summer of 1974. Two study plots were established in different plant associations in the northern portion of the seashore. Both plots had 36 trap stations placed 15 m apart in a 6 X 6-trap grid. Aerial coverage was approximately 1.44 acres. Initial work has begun. It is important that data continue to be collected over a long period of time.

Plots were positioned so that the beach area and a grasslands areas could be sampled. There were differences in species composition between the two plots. Only *Sigmodon hispidus* was collected on both plots. Plot I was located along the upper beach and dunes. *Dipodomys ordii*, *Spermophilus spilosoma*, and *Signodon hispidus* were collected. Kangaroo rats and ground squirrels occupied the more open areas, whereas, cotton rats were present in the thick grasses behind the sand dunes. Plot II had an almost uniform covering of thick grasses. Only *Sigmodon hispidus* and *Oryzomys polustris* were collected on this plot. Cotton rats were more numerous than rice rats. There was considerable diversity between Plot I and Plot II in rodent species density. The major factor involved the uniformity in both plant species and coverage area in Plot II, as compared to diversity in plant species and coverage in Plot I. This difference resulted in a larger rodent density per acre and a greater diversity of species in Plot I.

Work accomplished during the reported study period was restricted by a lack of time and familarity with the study area. Future work should progress at a more rapid pace.

PLANS FOR 1975: Research in 1975 will include: (1) Continued collection of rodent population data; (2) Expansion of plot size; (3) Random sampling over the extent of the seashore; (4) Establishment of 10-mile transects; and (5) Correlation of rodent distribution with vegetative units, including c^{13} studies. The present plan of operation should meet the stated objectives outlined in the proposal. There should be no major change in methods.

Financial support for 1975 was provided through a grant to Wiley College by the National Science Foundation (GY 10486). This grant has expired. The principal investigator has submitted a proposal for additional funding by the National Science Foundation. This proposal for approximately $22,000 includes funds for the Padre Island study. If this proposal is not funded, no funds will be available to continue the current project. If this occurs, a grant from the National Park Service will be necessary for the continuation of the project. It is estimated that $5,000 would be sufficient for continuance of the research.

# # #

TIDE AND CIRCULATION STUDY OF UPPER LAGUNA MADRE

INVESTIGATOR: Ned P. Smith
The University of Texas Marine Science Institute, Port Aransas

SUMMARY OF PROGRESS: Instrumentation and equipment were ordered and assembled in time to start the first of the two scheduled field exercises in late August 1974. Subsequent data analysis continued through the fall. The second field exercise began on 15 January and is scheduled for completion on 15 February. There have been no substantial difficulties affecting the timetable outlined in the original proposal.

SIGNIFICANT FINDINGS: Direct field observations suggest that wind-driven currents, highly variable in time, dominate the circulation of Upper Laguna Madre. Navigation channels provide for the return flow to the upwind side of the laguna. True tidal motions in the study site are of very small amplitude. The two principal diurnal tidal constituents have amplitudes on the order of 0.06 ft. Numerical filtering of a 148.5-day time series of water level data, removing tidal-period water level variations, indicates that approximately 92% of the water level variations occurring in Upper Laguna Madre are in response to meteorological forces. Discussions with Central Power and Light personnel have brought out the fact that 170,000 gal/minute (926,666 m^3/day) of water are removed from Upper Laguna Madre for cooling purposes. This may represent the most important single process in the flushing of water in the study area.

RECOMMENDATIONS: It is felt at this time that the Laguna Madre study should continue essentially as outlined in the renewal proposal for FY75. The site presently being studied is open-ended to the south. Tidal motions can enter Laguna Madre only from Corpus Christi Bay to the north. The wind-driven motions of water between the Kennedy Causeway and the Land Cut require that the study be expanded to include all of Laguna Madre north of the Land Cut to achieve an understanding of the dynamic flushing of this water body.

# # #

BEACH IMPACT STUDY, PADRE ISLAND NATIONAL SEASHORE

INVESTIGATOR:
E. W. Behrens)
R. L. Watson)
P. D. Carangelo) University of Texas, Port Aransas
W. H. Sohl)
H. S. Finkelstein)

SUMMARY OF PROGRESS: Introduction. The format for this study is simply the scientific method of observation, hypothesis, prediction, and experimental testing.

The initial observation was that where vehicular traffic is allowed, the beach consists of bare sand across much of the backshore (that part of the beach bounded by the top of the swash zone, the berm, seaward and by a permanent dune ridge landward) while where vehicles are prohibited, vegetation extends from the dune ridge almost to the berm. Furthermore, each clump of vegetation seems to act to some extent as a wind break, and a wind shadow sand dune forms in association with it.

The hypothesis formed from this observation is that the relative rates of sand accumulation on the two types of beach are different with the area from which vehicles are prohibited (coded Notraf) accumulating sand at a higher rate than the area with vehicular traffic (coded Vehtraf). This relative difference may occur, of course, anywhere on an erosion-deposition spectrum. Geologic evidence suggests that over the past few thousand years, erosion and deposition have balanced. If so, it must represent a dynamic equilibrium between obviously depositional processes such as the wind shadow dune formation and obviously erosional processes such as storm tide surges. If the change in the vegetation pattern enhances the depositional processes in the Notraf area and/or enhances erosion in Vehtraf, then this change may upset the apparent balance and lead to a progressively greater difference between these two areas.

One would predict that the volume of sand on the beach would be greater in the Notraf area because of more vegetation there, and that storm surge erosion will be greater in the Vehtraf area because of less vegetation protection. To test this prediction we proposed and have begun monitoring sand-volume changes in the two areas. Furthermore, to test the hypothesized correlation between vegetation and sand volumes, vegetational extent is also being routinely monitored.

This report outlines the results we have after about 0.5 year of work on this study. This period of time is not considered a valid test of our hypothesis because: (1) a full annual cycle of plant succession and wind regimes has not been observed; (2) a full range of climatic conditions has not been observed (annual rainfall in this region may vary by almost an order of magnitude); and (3) no storm surge has yet occurred during the study. What we have accomplished is some quantification of the differences that do exist in areas of different beach usage.

Study Areas. Four study sites were chosen to include more than just the two degrees of beach usage already referred to. From north to south they are: (1) Notraf is a site in the middle of several miles of beach from which vehicles are totally prohibited and pedestrian traffic is very light; (2) Pedtraf is a site from which vehicles are prohibited, but which is near a developed beach and campsite so that pedestrian traffic is moderate to heavy; (3) Vehtraf is a site with no usage restrictions and in which both vehicular and pedestrian traffic is moderate to heavy; and (4) Shell is within the shell beach areas which are accessible only with four-wheel drive vehicles so that vehicular and pedestrian traffic is light to moderate. All areas have readily identifiable limits which are the base of a well-vegetated dune ridge landward and the top of the intertidal zone (the berm) seaward. The width of the study zone between these limits is nearly the same at all sites (200-220 ft). Sand volumes were calculated from an arbitrary datum, -5 ft msl. An elevation profile was surveyed through each area approximately monthly from April through November 1974. Each line was divided into two parts: (1) the landward, vegetated segment; and (2) the seaward, nonvegetated segment.

RESULTS AND DISCUSSION: The majority of segments studied showed less than 10% change through the study period. The only exceptions were the losses of sand from the vegetated parts of Pedtraf and Notraf during early summer. This sand was apparently moved temproarily to the seaward part of the beach at least in the Notraf site and then returned to the landward part the following month. Whether or not this apparent stability is maintained throughout the year is impossible to say as yet, because only one mode of the bimodal wind system has been observed. The onshore, southeasterly wind mode has been dominant through the study period so far. North and northeasterly winds will become dominant in the winter months.

The shell beach is particularly stable probably because the shell material forms a protective pavement from which little sand is moved except by major storm events.

A somewhat more surprising observation than the monthly stability of the sand volumes is the nearly equal total volumes of sand at the different study sites. The cross sectional area from the arbitrary datum (-5 ft msl) to the land surface equals the volume in cubic feet per linear foot of beach. This value is about 2400-2600 ft^3 in all cases.

The relative values in the vegetated and unvegetated parts of each backshore do vary considerably. In the Shell site the unvegetated portion has ober 1200 ft^3 while the vegetated part has only about 1100 ft^3. At Vehtraf the unvegetated portion has between 1000 and 1100 ft^3 and the vegetated portion has about 1600 ft^3

The difference at the more protected sites is even greater with the vegetated to nonvegetated sand volume ratios for Notraf and Pedtraf being 1800:600 and 2100:300 respectively.

The greatest amounts of sand in the vegetated portions of the backshore correlates directly with the greater widths of these zones. In the same order of sites given above, the vegetated zone widths are: 90 ft, 110 ft, 160 ft, and 170 ft.

Vegetation. The character of the vegetation has been studied most intensively in the two areas of greatest contrast, Notraf and Vehtraf. In Notraf, three zones are identified. In the seaward-most zone, low solitary dunes are vegetated usually by a single species. Only three species are common: *Sesuvium portulacastrum*, *Ipomoea pez-caprae*, and *Uniola paniculata*. These are pioneer types of halophytes capable of rapid upward and lateral growth. The next landward zone also has three dominant species: *Uniola paniculata*, *Ipomoea stolonifera*, and *Spartina patens*. The latter two are characteristic of broad areas of coalesced dunes. Also, *Uniola* is joined by five other species of dune builders such as *Amaranthus gregii* and *Croton punctatus*. Thus, the plant diversity is greater with consequently greater variety of types of leaf baffle and cover and greater variety of root binding systems. In the third, landward-most zone both topography and plant species diversity are even more varied. The number of common species increases to 15 presumably with a consequent increase in diversity of characteristics. The greater overlap of ranges of annuals and variety of trapping and holding systems is thought to increase the stability of the sediment in this zone.

In contrast to Notraf, only two vegetation zones are recognized in Vehtraf. They are most similar to zones one and two in Notraf. The seaward zone has more or less discreet dunes of *Ipomoea pez-caprae*, *Ipomoea stolonifera*, and *Uniola paniculata*. The landward zone has higher, steeper, interlocking dunes but only six species are common. In all zones in both areas about a half dozen additional species can also be found; but these are quite rare and are not considered significant in the dune building or stabilizing process.

CONCLUSIONS: Evidence is negative that a greater extent of vegetation on the backshore leads to a greater volume of sand accumulation in the subaerial portion of the beach, at least at the stage of development of the studied beaches. This probably means that all of the sand that is supplied to this zone is trapped by the vegetation within it, regardless of the width of the vegetated portion, so long as there is a significant width of vegetation. It is conceivable that this may not be the case in a longer time interval, because the dunes will ultimately have height limitations, and unless these decrease rapidly seaward, the wider vegetated zones should be able to grow as high as the narrower vegetated zones and thus ultimately accumulate more sand.

The differences in vegetation support the hypothesis that the wider vegetation zone will be more resistant to storm surge erosion, but in the absence of a storm surge, this prediction has yet to be tested. Also unanswered is the question, how much does the vegetation and sand volume pattern we now see vary with extremes of rainfall? The present conditions represent the development under the greatest supply of fresh water because the area has been in a wet mode for several years. Normal, dry, and drought periods could reduce the fresh ground-water supply by over 50% and this could produce a considerably different pattern on the backshore. to answer these questions, the study needs to continue for a much greater period of time than it has been underway.

Pedtraf and Shell have not been studied so intensively; but Pedtraf appears so similar to Notraf that it is felt that a different study site should be substituted for it so as to increase the diversity of the study sites. Shell, on the other hand, is too different from the other sites to make such comparison. There, vegetation zones are often separated by vehicular traffic patterns, and substrate and exposure patterns vary widely.

# # #

PETRIFIED FOREST NATIONAL PARK

STUDIES IN THE MICROENVIRONMENT OF THE CHINLE FORMATION

INVESTIGATOR: Terah L. Smiley
University of Arizona

SUMMARY OF PROGRESS: Nearly all research during the year was concentrated on geochemical problems aimed at obtaining an understanding of the types, concentrations, and associations of various elements present in the petrified wood (Progress Report titled "Preliminary Geochemical Investigations of Silicified Wood," by Anne Sigleo, 1974). A copy of this report was forwarded to the superintendent last summer. Continuing work on problem areas, as indicated in the preliminary report, has resulted in additional information and several modifications of the text.

The major difficulty in the understanding of the petrification is the silicification processes themselves. A proposal for detailed research is being prepared and will probably soon be submitted to the National Science Foundation for their consideration.

The lack of funding is slowing the work but once the silicification of the logs has been satisfactorily understood, the geochemical environment can be determined and we can move on to a better understanding of the microenvironment responsible for the Chinle Formation.

# # #

PRELIMINARY GEOCHEMICAL INVESTIGATION OF SILICIFIED WOOD

INVESTIGATOR: Anne Sigleo
University of Arizona

SUMMARY OF PROGRESS: Geochemical analyses of a silicified twig and the sediments surrounding it from the Petrified Forest National Park were made to study the geochemical environment and nature of wood silicification. The crystal form of the quartz present in the wood was determined by X-ray diffraction analysis and quantitative trace element analyses were made to evaluate the relationship between the concentrations of different metals and the colors present in the sample.

This preliminary investigation demonstrated the feasibility and value of instrumental neutron activation analyses for measuring major and trace elements in these samples. The elements determined include U, Al, K, Na, Fe, Co, Sc, Rb, Ba, Sr, Cr, Mn, Zr, Sb, Cs, La, Ce, Nd, Eu, Tb, Yb, Lu, Hf, and Ta.

# # #

PLATT NATIONAL PARK

RESEARCH ON SUBSURFACE AND SURFACE WATER FLOWS, PLATT NATIONAL PARK

INVESTIGATORS: J. F. Harp) University of Oklahoma, Norman
J. G. Laguros)

SUMMARY OF PROGRESS: Data has been accumulated and hydrologic and hydraulic analyses are in progress. An unexpected complication of this problem has been the difficult geologic formation present in the research area. Unexpectedly, Travertine Creek has been found to be effluent between Buffalo and Antelope Springs and the Travertine Nature Center. It is already evident that flow-recording stations must be established within the park so that a monitoring of the flows can be made. It is anticipated that the project will be completed as scheduled in the original contract.

# # #

POINT REYES NATIONAL SEASHORE

RESTORATION OF TULE ELK

PORE-N-7

INVESTIGATORS: Richard M. Brown, et al

OBJECTIVES: 1. Determine the carrying capacity of the habitat with the proposed enclosure.

2. Determine the number, ages, and sex ratios to be represented in the initial restoration of tule elk to the seashore.

3. Carry out extended monitoring of the vegetation before and after reintroduction of the tule elk.

4. Determine management problems that are likely to result from restoration of these animals to the seashore and provide alternative ways for resolving these problems.

METHODS: Identify appropriate study sites, both inside and outside the elk enclosure.

Establish transects, plots, and exclosures on the selected study sites to determine pertinent relationships of the vegetation to the elk and associated ungulates, both native and exotic.

RESULTS AND DISCUSSION: The proposed 2600-acre site on Tomales Point continues to be the preferred location for restoration of the tule elk to the seashore. It has been so identified in the draft Natural Resources Management Plan, upon whose approval depends the implementation of this project. A Form 10-238 has been submitted for this project; it constitutes a part of package #150 and currently carries a #5 park priority.

Michael J. Moratto, Department of Anthropology, San Francisco State University, visited the park in mid-April 1974 to examine the site of the fence line and associated structures for archeological significance. He advised that his findings were negative, and his subsequent report gave archeological clearance for this project on the specified site.

PLANS FOR 1975: The top priority objective with respect to this project is to complete and obtain approval for the Natural Resources Management Plan. The final draft of this plan is now nearly complete, and its implementation by July 1975 is expected. Tomales Point, at least in part, has been suggested by various individuals (and organizations) for designation as a wilderness area. Such status might affect the location and construction of the fence and associated structures.

With an assumption that Tomales Point will remain a viable site for tule elk restoration to the seashore, and with approval of the Natural Resources Management Plan, vegetation plots, exclosures, and transects will be established on the tule elk enclosure site. These will serve to describe and monitor the vegetation, providing a baseline against which future changes can be measured, and will ultimately determine the optimum carrying capacity of these 2600 acres for tule elk.

References

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# # #

PRESCRIBED BURNING, BISHOP PINE FOREST

PORE-N-8

INVESTIGATORS: Richard M. Brown
John Aho
Charles Rickart

OBJECTIVES:

1. To determine the natural conditions and processes of bishop pine forest, especially with respect to fire.
2. To determine the manner in which fire should be used as a management tool to help restore the natural conditions to this forest.

METHODS: Prepare a detailed, large-scale working base map of the proposed 3-4-acre site. Obtain pertinent data on environmental factors, including light, air temperature and humidity, slope, and soil conditions.

Determine major floristic and faunistic elements of the area, with emphasis on vascular plants and vertebrate animals. By means of quadrats and transects, determine species coverage by major plant species. Individually number all trees on the site that are 6 inches or more in diameter (dbh). For each of these trees, obtain data as to species, dbh, and general condition and, by means of an increment borer, determine ages of selected trees.

Establish a fire-weather station to obtain data required for the prescribed-burn formula. Establish in the site vicinity a control area having as similar conditions to the burn site as possible.

RESULTS AND DISCUSSION: Additional data were obtained for the experimental burn site, including seed production and dispersal, species coverage, and amount of drip from moisture condensation at the prescribed-burn site.

The fire-weather station operated daily throughout the period June through October. Readings were taken once a day for all factors comprising the prescribed-burn formula.

This provides a continuous record for the 5-month period during which natural fires are believed to have had highest frequency and, consequently, the one during which prescribed burning should be carried out.

Explorer Post 30, sponsored by the Bechtel Corporation, San Francisco, completed the mapping of this site. Printed copies were received in three formats: one showing individual, numbered trees; one showing contours; and one combining trees and contours.

Two preliminary trap nights, using small mammal live traps on a grid system, produced only two mice and suggest that population levels for such animals are exceptionally low.

It should be emphasized that this initial prescribed burn is an experimental one. It seeks not only the needed biological data to describe the community under pre-burn conditions and at various stages of its post-burn development but also to provide managers with experience in prescribed burning of a particular vegetation type at a specific stage in its development. It appears that, because of the necessity for adequate safety precautions with regard to the public, assorted structures, and the adjacent vegetation, this prescribed fire will be conducted at a level of heat intensity that is less than optimum for natural fires in Bishop Pine Forest.

PLANS FOR 1975: Implementation of this prescribed burn depends upon the approval of either the local Natural Resources Management Plan or a broader regional or service-wide plan for fire management. The seashore's Natural Resources Management Plan is now nearly completed in final draft and is expected to be approved for implementation by July 1975. Under such a schedule, experimental burning of the selected site will take place in the latter part of 1975 when the prescribed-burn formula has been met, presumably in the fall of the year. The fire-weather station will be reactivated early in that period to obtain the necessary data for the burn formula.

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# # #

ECOLOGICAL WILDLIFE STUDY: DEER

PORE-N-1

INVESTIGATORS: Oscar Brunetti, et al.
California Department of Fish and Game

SUMMARY OF PROGRESS: Monthly collections of axis and fallow deer continued throughout the year. Approximately five individuals of each of the two species were taken each month. The first quarterly progress report was distributed at the annual meeting of personnel of the California Department of Fish and Game and of Point Reyes National Seashore in February 1974, in accordance with our memorandum of understanding. No other reports were supplied to the seashore during 1974. The annual report, covering the first year's activities--October 1973 through September 1974--is expected to be ready for the annual meeting in February 1975.

In December 1974, this project was expanded to include sampling of the native black-tailed deer.

An agreement was reached during the year to extend this study an additional year through September 1975.

# # #

MANAGEMENT OF BEACH AND DUNE VEGETATION

INVESTIGATOR: Michael G. Barbour
University of California, Davis

SUMMARY OF PROGRESS: Our objective is to exclose portions of beach and dunes at Point Reyes National Seashore that have been disturbed by foot traffic or plant introductions. We will evaluate the use of several native plant species to hasten recovery to a natural landscape while maintaining or enhancing stability. Field plantings and observations will be augmented by greenhouse trials.

Plantings of American dunegrass (*Elymus mollis*) in various densities and with various slow-release nitrogen levels added, occupy about 170 m^2. We are also examining the competitive interaction between *Elymus* and introduced European beachgrass (*Ammophila arenaria*). Other plots of undisturbed *Elymus*- or *Ammophila*-dominated vegetation have been located, sampled, and photographed.

Vegetative and seed propagation work in the green house has revealed several native species which are easy to work with, and several others for which propagation is still difficult. Other trials indicate that seedling tolerance to salt spray and salt-water inundation is not uniform from species to species.

At the end of the study we should know the identity of several native species which can be used to stabilize beach-front acreage in combination; we should have worked out methods for propagating such species; we should have estimates of sand movement in reestablished communities; we should know the effect of foot traffic on stability; and we may be able to,guess at the amount of time required to reestablish a natural beach community.

# # #

SOCIAL RELATIONS IN THE "SOLITARY" RODENT *NEOTOMA FUSCIPES*

INVESTIGATOR: Kurt Wallen
University of California, Berkeley

SUMMARY OF PROGRESS: During the spring of 1974 a population of woodrats (*Neotoma fuscipes*) was followed for 3 months by trapping, ear tagging, and releasing. It was found that there were two classes of animals, residents and transients. Residents were always found in the area, often (in the case of females) in the same house, for at least 3 months. Transients on the other hand were rarely in the area for more than 2-4 weeks before disappearing. This work suggested that woodrats live in groups in which individuals must be capable at least of discriminating group members, or residents, from transients. It is suggested that the role of the house in survival of individuals and reproduction in the group necessitates a group organization. The house is a limited resource see Linsdale and Tevis, *J. Mammal.*, 1955), and as such there must be a mechanism that will ensure its availability to the resident population. A series of pilot studies done in the lab by the author suggest that the woodrat is a highly social animal, having an extensive and variable repetoire of social behaviors; that it reacts in a friendly fashion to familiar animals and hostilely to strangers. It is suggested that woodrats live in social groups which are unusual in that individuals are able to maintain exclusive control of the house in which they live, and yet they interact non-agonistically with other members of the group while excluding non-members.

Currently a population of woodrats is being studied in the field so that spatial relations and house utilization patterns are known. Then the population will be moved to the laboratory for a series of experiments to study social reactions to strange and familiar conspecifics as well as possible use of odors to communicate information. This work should be completed in 4 months, contributing to the information on an unusual but little studied rodent.

# # #

LIFE HISTORY OF BATS ON SEASHORE PROPERTY

INVESTIGATORS:
James Patton)
Phil Myers) University of California, Berkeley
Robert Jones)

SUMMARY OF PROGRESS: All carcasses have been processed for accessioning in the Museum of Vertebrate Zoology, University of California, Berkeley. Scientific data are permanently preserved together with voucher specimens of this material The following species were found:

Myotis yumanensis	162	*Tadarida brasiliensis*	4
Myotis californicus	14	*Antrozous pallidus*	8
Myotis thysanodes	7	*Eptesicus fuscus*	3

A small series of morbid animals discovered on 13 June were tested for the presence of rabies. Negative results were obtained. The laboratory of the Biomedical Research Center of UC processed the tissue.

A continuation of monthly observations this year will allow additional biological data to be gathered.

# # #

WINTER FORAGING AND SOCIAL BEHAVIOR OF THE GOLDEN-CROWNED AND RUBY-CROWNED KINGLETS

INVESTIGATOR:
Robert M. Stewart
Point Reyes Bird Observatory

SUMMARY OF PROGRESS: During the 1973-74 season, we examined the foraging behavior of both species in the alder and the broad-leaved forest habitats on the seashore.

We have been banding these two species here since 1967 and as a result are getting survival rates on them also.

# # #

MARIN HERONRY STUDY

INVESTIGATORS: Helen M. Pratt)
Dale Elliott) Point Reyes Bird Observatory

SUMMARY OF PROGRESS: Two of the known heronries in Marin County are located within Point Reyes National Seashore.

The Schooner Bay heronry, behind the Johnson Oyster Company, is reported upon for the 1974 season in the *Point Reyes Bird Observatory Newsletter* (32):4-6. Fifteen breeding pairs were recorded in the eucalyptus grove. At the 13 observable nest interiors, an average of 1.9 young were raised by each pair.

The heronry off the Horse Trail was inactive in 1974 for the second consecutive year.

# # #

NESTING STUDY OF THE ORANGE-CROWNED WARBLER

INVESTIGATOR: Robert M. Stewart
Point Reyes Bird Observatory

SUMMARY OF PROGRESS: Nests of the Orange-crowned Warbler were observed during the breeding season. Various aspects of the breeding behavior--including foraging behavior, clutch size, incubation time, nestling development, and breeding success--and survival rates were examined.

In the 1974 season there was a marked decline in breeding success.

# # #

DOMINANCE STUDY OF THE WHITE-CROWNED SPARROW

INVESTIGATOR: Robert M. Stewart
Point Reyes Bird Observatory

SUMMARY OF PROGRESS: Field work has been completed. Data analysis will be carried out during 1975.

# # #

BREEDING-BIRD CENSUSES

INVESTIGATOR: Robert M. Stewart
Point Reyes Bird Observatory

SUMMARY OF PROGRESS: In spring 1974, PRBO continued censuses of breeding land-birds at eight selected sites on Point Reyes National Seashore. These censuses will be published in detail in *American Birds*.

A summary of the 1974 censuses and a comparison of these with the 1972 and 1973 censuses appears in the *Point Reyes Bird Observatory Newsletter*. (31):2-3.

The eight sites censused included two each of disturbed coastal scrub and of bishop pine forest, and one each of undisturbed coastal scrub, mature Douglas fir, logged Douglas fir replanted to Monterey pine, and oak-bay mixed forest.

Of 21 common species censused in spring 1974, 15 were resident species and 6 were migratory species. In comparison with 1973, five of the magratory species declined in numbers and one increased. Of the 15 resident species, 12 declined in numbers from 1972 to 1973. Of these 12, 7 species appeared to be holding their own in 1974 and 5 species increased in numbers. The other three resident species declined in numbers.

Red Crossbills exhibited breeding behavior in three of the study areas.

# # #

AVIFAUNAL CENSUS OF LIMANTOUR ESTERO

INVESTIGATORS: John Smail) Point Reyes Bird Observatory
Gary Page)

SUMMARY OF PROGRESS: Tri-monthly censuses are made of Limantour Estero during each month, September through April. Ultimately, a record will be compiled of the seasonal and yearly variation in population numbers. Because of the dry winter, 1974-75, the population of waterfowl has remained higher than normal, probably as a result of the unavialability of other usual feeding areas.

The molt of the western sandpiper was recorded during the period July through September The timing of the molt was documented for comparison of that at Limantour Estero with that of other areas outside the seashore. A small amount of invertebrate sampling of the mud substrate was done to determine available food. A few stomachs were pumped to determine what food was being taken by the western sandpiper during molt. Some censusing was made of the habitat use by four species of plover.

# # #

THE ECOLOGICAL ASSOCIATIONS OF INSECTS AND PLANTS

INVESTIGATORS: Evert I. Schlinger) University of California, Berkeley
Peter A. Rauch)

SUMMARY OF PROGRESS: We are continuing to collect insect-plant associated data for our computer-based data file on two primary areas of the national seashore: (1) the North Beach Dune, and (2) the Inverness Ridge.

We are also studying several different ecological phenomena, some of which include: (1) dune spiders and their parasitoids; (2) pollination schemes of several plants in both areas; (3) the insect fauna associated with *Lupinus arboreas*; (4) the absence of insect fauna associated with *Ammophila arenaria*; and (5) the overall effect of man's activities on the beach area and dunes with respect to the destruction of insect populations and have some selected plants (mostly native annuals).

# # #

FOOD HABITS OF SALVAGED MARINE MAMMALS

INVESTIGATOR: Robert E. Jones
University of California, Berkeley

SUMMARY OF PROGRESS: During 1974 I collected the following four specimens under permit from PRNS: 1 *Zalophus californicus*--skull, baculum and stomach; 1 *Zalophus californicus*--skull, baculum and stomach; 1 *Mirounga angustirostris*--parts of skull, baculum, stomach and vertebrae; 1 *Phocoena phocoena*--skull and stomach taken; stomach returned to PRNS collection after cleaning; stomach empty.

Standardized data sheets are deposited at headquarters PRNS. Continuation of reporting all dead specimens aides in basic biological data preservation.

# # #

POPULATION ECOLOGY OF GRANIVOROUS BIRDS

INVESTIGATOR: Robert M. Stewart
Point Reyes Bird Observatory

SUMMARY OF PROGRESS: We are examining several aspects of the winter ecology of the following species: Golden-crowned Sparrow, White-crowned Sparrow, Fox Sparrow, Rufous-sided Towhee, Brown Towhee, Wrentit, Song Sparrow, and Scrub Jay.

In addition, we are looking at various aspects of the breeding biology of the White-crowned Sparrow.

As a result of these studies, some individual birds, including Scrub Jays and White-crowned Sparrows, are now known to be at least 8 years old.

# # #

EFFECT OF TILLAGE ON DISEASES OF NATIVE PLANTS

INVESTIGATOR: C. E. Yarwood
University of California

SUMMARY OF PROGRESS: The main, new effort in 1974 was a comparison of the effect of tillage on disease at three levels of plant growth. At the upper level (near the road) volunteer *Baccharis pilularis* had grown to an average height of about 3 ft in 20+ years. At the intermediate level, (western end of lot 81) the volunteer *Baccharis* averaged about 5 ft, and at the lower level (near edge of canyon) the *Baccharis* averaged about 7 ft. Circular areas about 10 ft in diameter were cleared by cultivation during the winter months; non-*Baccharis* growth was suppressed by cultivation in three plots and by the herbicide Paraquat in two plots. Subsequent growth of *Baccharis* and development of the mildew *Erysiphe cichoracearum* was roughly proportional to the previous growth of *Baccharis*.

The only 1974 publication clearly related to this project was a list of powdery mildews of California, including several found for the first time in the United States and in some cases in the world in Point Reyes National Seashore, and in some cases only where the soil was experimentally tilled.

# # #

Redwood National Park

WATER QUALITY SIMULATION STUDY
REDW-N-12

INVESTIGATORS:
S. M. Zand)
M. J. Sebetich) U. S. Geological Survey
V. C. Kennedy)

SUMMARY OF PROGRESS: During 1974 initial baseline biological study of Little Lostman Creek was carried out. The study reach extends from near the bridge, 0.75 mil upstream. The three selected observation stations are at the two boundaries and at the midpoint of the experimental reach.

A continuously recording partial flume was installed at the bridges and operated during the dry season. A standard U. S. Geological Survey gaging station was installed at the midpoint and operated continuously during the year. Physical-chemical measurements included pH, dissolved oxygen, conductivity, temperature alkalinity, and concentrations of various natural chemicals (N, P, Ca, Mg, Si, S, Na, Cl).

Composite samples of obvious organisms, mainly insects and algae, were taken by hand bu no quantitative estimates made. A 24-hour study was conducted during which dissolved oxygen, temperature, conductivity, seston, insect drift, and other environmental and physical chemical variables were determined. Two short-term tests to estimate rates of primary pr ductivity of various species of algae were made at the bridge and mid-section.

During the coming season, additional baseline data will be accumulated and growth-limiting nutrients determined. Approximately four additional seasons of work will be require for the construction and testing of water quality mathematical models generated from this study of a natural stream in which there have been few cultural changes.

# # #

STREAM MONITORING SYSTEM STUDY
REDW-N-11

INVESTIGATOR: Richard W. Janda
U. S. Geological Survey

SUMMARY OF PROGRESS: Synoptic sampling on tributaries to Redwood Creek was carried out for three storm events (January, February, March) during 1974 water year, and two summer diel periods (July, September) and two storm events (October, November) during the early part of 1975 water year. During the last two sampling periods, five sites in different management units associated with Louisiana-Pacific's M-7-5 harvesting unit and Redwood National Park were incorporated into the program. Data collected in this phase of the U. S. Geological Survey program suggest the following:

1. Unit storm dishcarges for streams draining sandstone terrain were significantly greater than those for streams draining schist terrain.

2. Recent cutover land is associated with greater storm runoff and higher sediment loads than uncut land. Increased sediment loads persist longer than increased sediment concentration.

3. Dissolved constituents are as concentrated in runoff from cutover land as in that from uncut land; that is to say that there is no dilution effect to correspond with the increased runoff.

Redwood Creek erosion process maps (1:62,500) were updated and improved on the basis of 1974 photographs and additional field work. Several small scale midslope failures occurred in cutover and uncut land during last winter. The most ominous of these occurred on the slope above "the Elbow" upstream from the Tall Trees Flat; this failure could easily enlarge downslope into the park and merge with the unstable area immediately adjacent to the stream channel. The largest single new slide in the basin occurred on the left valley wall immediately adjacent to Redwood Creek in the vicinity of Lake Prairie Creek. The detailed strip map of Redwood Creek (1:5,000) was also updated on the basis of 1974 photographs and detailed field traverses. Buried stumps associated with 1964 flood gravel berms indicate that a widespread aggradational event comparable to the 1964 event had not occurred within the basin during at least the preceeding 300 years.

All 42 monumental stream channel cross-sections established on Redwood Creek prior to the 1973-74 storm season were resurveyed at least once. Channel widening and bank cutting were prevalent throughout the basin. Net bed scour occurred at most sections upstream from Bridge Creek, whereas net channel aggradation was prevalent downstream from that point. Eight more cross-sections were established in order to isolate the impact of specific tributaries and to understand better the channel behavior upstream from Highway 299.

In the Mill Creek basin, 10 monumented channel cross-sections have been established and a photo interpretive map (1:24,000) has been completed.

In order to understand more completely and quantitatively the processes responsible for the sediment loads observed at our stream monitoring sites, numerous monumented stream channel cross-sections were established in the tributary basin, clusters of hillslope erosion and deposition pins were installed, and repetitive photography stations were established.

In landslide monitoring, all stake lines established prior to or at the start of the 1973-74 sotrm season were resurveyed at least once. Thirteen new stake lines were established and many of the old and new lines were equipped with strain rhombs. This phase of the U. S. Geological Survey program now consists of approximately 35 lines on 10 different slides and earthflows. Eight cased holes were drilled for creep studies using a pendulum-activated wheatstone bridge inclinometer in cooperation with the U. S. Forest Service. Observations made during 1974 storm season suggest that enormous quantities of sediment leaves slide areas by fluvial transport as well as en masse. Studies have been started to quantify this relationship. Two additional recording rain gauges were installed as part of this activity.

Monumented cross-sections and photo-stations were established to document the changing morphology of the estuary of Redwood Creek. Changes in water chemistry, temperature, and stage were monitored through multiple tidal cycles on two separate occasions. In the estuary as well as at several sites along the main channel and in some tributaries, pre-dawn summer dissolved oxygen levels were far below water quality standards.

Studies of stream biology and water chemistry discussed in the project proposal, as well as an expanded study of inter-gravel dissolved oxygen concentration, are proceeding on schedule under the direction of R. C. Averett.

# # #

FASCIATION IN REDWOOD STEM TIPS

INVESTIGATOR: Stephen D. Veirs, Jr.

OBJECTIVES: Fasciation in stem tips of the coast redwood (*Sequoia sempervirens*) is an anomaly which has been previously reported with only speculation presented regarding causality. Observation of an area of high incidence of fasciation suggested that some work might contribute to an understanding of factors involved in the initiation of this condition.

METHODS: Following a chance observation in 1972 of fasciation in a roadside redwood tree on private land near Crescent City, California, additional fasciated stem tips, both apical and lateral, were observed and photographed in several trees. Additional field work resulted in the location of additional fasciated trees. These were described with particular attention to annual growth segments and redescribed and photographed annually.

RESULTS AND DISCUSSION: Because this initial concentration of fasciated trees was immediately adjacent to a new highway, I thought it possible that the fasciations may have been induced by factors related to the highway construction or subsequent maintenance. Especially suspect was the possible use of herbicides containing 2,4-D and 2,4,5-T which strongly interfere with normal stem-tip physiology in dicot plants, although conifers are less sensitive to external applications of these hormones. This hypothesis could be tested by examining the time of the initiation of the fasciations observed. The results, however, eliminated this possibility as a causal factor, as fasciations predating the road by several years were eventually observed. 2,4-D and 2,4,5-T are utilized in this region for controlling broadleaved trees and releasing coniferous tree reproduction. Foliar application of oil-based sprays containing these agents do cause abnormal growth in redwood characterized by abnormal lateral stem elongation and curling, leaf curl and chlorosis. However, no fasciated stems were observed in such specimens.

The area studied was second growth redwood vegetation logged before 1900 and allowed to regenerate naturally. No other specific details of subsequent disturbance, if any, are known. It is located north of Crescent City, California, on the Smith River plain at an elevation of 60-70 ft, 5 miles from the Pacific Ocean. The soil is a loam developed from a sedimentary rock alluvium high in quartz and clay, with little local relief. The mean annual rainfall varies from 60 to 100 inches. Summers are cool and dry but foggy. Winters are mild and wet. Mean annual temperature is 52°F with a July average of 55°F and January average of 45°F.

The fasciated stems were observed in second growth trees varying in height from 15 to 60 ft. Approximately 20 separate plants with fasciations were observed in an area of approximately 20 acres. They represented an estimated 5-10% of all redwoods in the area examined. One prostrate tree supported about 20 vertical stems which probably were initiated after the tree fell. Most contained fasciations. Fasciation in redwood is a proliferation of stem tips along a single vertical plane as a consequence of an abnormal cell division sequence in the meristem. A fasciated stem may be constituted by as few as 2 or 3 laterally contiguous apical buds to as many as 90 (observed) or more. These result in a flattened mass of stem tissue, slightly ribbed below each bud, with leaves and axillary buds along its length. When examined, a single continuous pith was present. Generally, when only a few stem tips constitute the fasciation, the vertical growth of the compound stem is similar to that of a normal stem. In larger fasciations, however, one part of the fasciation commonly grows more rapidly in length than the rest and the resulting stress results in bending and contortion of the growing mass.

A normal stem tip photographed in 1972 was observed to have fasciated when examined after the next growing season. In other cases fasciated stems frequently displayed subsequent normal stem development from both apical and axillary buds of fasciated tissue. In several cases the "normal" stems elongated rapidly and became dominant leaving the fasciated tissue behind, suppressed and eventually dying as the main stem grew vigorously.

In a 60-ft redwood, fasciation was observed to have occurred in two leaders which were produced following top damage which had occurred 3 or 4 years previously. One stem appeared to have fasciated in 1968, the fasciation yielding dominance to a normal stem elongating from the fasciation. The second fasciated once in 1968 and continued its growth in length through a normal-appearing stem which was again fasciated when observed in 1973.

During the period of these observations I have seen several other fasciated second growth redwoods in Del Norte and Humboldt counties similar to those reported here. In addition, a logger gave me a fasciated redwood sprout more than 4 ft in length. It was produced in one growing season from the stump of a freshly felled tree.

Fasciation has not been reported for old growth canopy trees but it may occur none the less.

CONCLUSIONS: The cause of fasciation in redwood remains unknown, however, the use of herbicides containing plant growth hormones does not appear to be related to its occurrence. Whatever causes this anomalous growth, fasciation does not terminate stem growth in length, as the fasciation is commonly replaced by a normally growing stem tip, usually an axillary bud in the fasciated tissue which becomes dominant because of the apical positioning resulting from the downward curling growth of the fasciated stem mass.

Whether fasciation is a commonly occurring "natural" apical chimera or the result of disease, damage, or some unknown agent, the net effect of this phenomenon in redwood appears insignificant.

# # #

SUCCESSION ON CUTOVER LAND
REDW-N-3

INVESTIGATOR: Stephen D. Veirs, Jr.
Redwood National Park

OBJECTIVES: To document plant succession on cutover forest lands within Redwood National Park, to determine the probable future of the second growth vegetation and to suggest management which may direct the succession along lines that will result more or less rapidly in the development of vegetation similar to that removed by logging, if appropriate.

METHODS: A series of permanent vegetation transects have been established in representative sites in areas of former forests cut before the establishment of Redwood National Park. Sampling to determine the nature of the second growth or post-disturbance vegetation has included determination of species, number, size, cover, and related data for trees and other plants found on the area sampled.

RESULTS AND DISCUSSION: Prior to 1974 plots were established in second growth approximately 5 to 20 years following logging. While the results of this work have not been completely analyzed, it is apparent that the bulk of the cutover land is becoming reforested with native tree species. Shrubs and herbaceous species include both native and exotic species, some of which are common associates of old growth redwood forest and some of which are clearly disturbance-related species.

During 1974 additional permanent vegetation plots were established in older second growth forests within the park and in Del Norte Redwoods State Park. These varied in age from 20 to 40 years, the oldest located in areas that were clear-cut and cable-logged by the Hobbs-Wall Company of Crescent City during the early 1930s. These areas are similar in many ways to the modern redwood clear-cuts except that no track-laying tractors were used and no planting or seeding followed.

Additional sampling and a detailed analysis of the data remain to be done, however, preliminary observations suggest several noteworthy points. Redwood sprouts display excellent growth in height and diameter followed by Douglas fir which occurs in greater numbers. Redwoods established from seed are suppressed by the canopy trees but persist as an element of the second growth stand.

Eventual stand composition, say at age 100 years, has not been postulated. Presently, however, Douglas fir is comparatively over-represented, a consequence which must be anticipated as a natural result of the post-logging regime. Douglas fir numbers continue to decline as a result of mortality due to competition and suppression of slow-growing individuals.

Exotic plants are absent from the canopy and understory of the older (30-40 years) second growth stands. Common native understory species are becoming reestablished as the stands begin to open up. This aspect of the second growth succession is desirable from the standpoint of resource management objectives of the National Park Service as no exotic plants means no control problems.

Since Douglas fir is a long-lived species, its over-representation in the canopy might persist for 300-400 years before redwood assumes its more normal status. If more rapid establishment of a more nearly natural forest is desirable, then manipulation to change the redwood-Douglas fir canopy tree ratio should be considered as a part of the long-term management of the second growth forests.

# # #

COOPERATIVE REMOTE SENSING STUDY (PILOT PROGRAM DEVELOPMENT)

REDW-N-8

INVESTIGATORS: Randy Thomas, Forest Remote Sensing Laboratory, UC, Berkeley
T. F. Hatzimanolis, Redwood National Park

SUMMARY OF PROGRESS: A Cooperative Agreement was signed. The scope of accomplishment is as noted below. A report: "Preliminary Study of Remote Sensing Data to Inventory and Monitoring of Resources within and Adjacent to Redwood National Park" was issued July 1973 by Remote Sensing Research Program, University of California at Berkeley.

Accomplishments to Date. The major conclusions from the North Coast Test Site northern study area project based on manual image interpretation only are as follows:

1. ERTS-1 multi-band color composite image types can be useful information sources for determining topographic position, general slope class, land-use pattern, land-use change, location and extent of recent and past harvesting activity, snow-pack location, snow-pack change, and river sediment plume activity.

2. ERTS-1 color composites can in some cases be used to map very broad categories of vegetation type and stand density. Some information on geologic units and the extent of bays, lagoon, and large stream channels may also be obtained from ERTS-1 color composite and band 7 image types utilized in this study.

3. ERTS-1 band 5 appears to be most useful for monitoring change in land-use pattern, location and extent of recent harvesting activity, snow-pack location, and sediment activity.

4. ERTS-1 images were not useful, or only indirectly useful, for location and characterization of resource management problem areas.

5. High altitude U-2 photography is generally very useful in the detection, delineation, and identification of resource management problem areas and ecosystem resource features. All three U-2 image types examined are especially good information sources for the analysis of (a) active soil mass movement areas, (b) detection of present and potential locations of bank undercutting via stream action, and (c) analysis of site factors which would dictate the appropriate harvesting techniques to employ for a given location. In these cases the 1:15,875 U-2 image format has a detectability rating at least one class above that for the 1:37,500 images. The larger scale 1:15,875 photos are also the best U-2 information source among those examined for the detection, delineation, and identification of potential soil mass movement areas and potential road failure locations.

6. Most resource features, except species composition and slope class, were interpretable from the U-2 photo enlargements. The 1:15,875 U-2 image allowed the greatest ease of detection or assessment of forest harvest methods, forest regeneration methods, and dates of harvest. The 1:15,875 photo also gave the highest resource feature identification rating.

7. The 1:15,875 U-2 image type appears to be an optimal map base for the widest array of management problems characteristic of the California north coast. U-2 1:37,500 enlargements are less useful as management problem map bases, while ERTS-1 1:125,000 enlargements are not appropriate for this task.

The ranking of these types of imagery in terms of their utility as a resource feature map base follows the same order as above. However, the U-2 1:37,500 prints are often useful map bases depending on the variability of the resource parameter. ERTS-1 1:125,000 images have good map utility for recent forest harvest activity location and land use pattern delineation.

8. The optimum combination of high altitude and earth orbital imagery utilized by a resource manager in the California north coast region will depend on the level and type of his information needs, and the most efficiency of utilizing these remote sensing techniques. One optimum combination for organizations with large land management responsibilities is a U-2 1:37,500 map base system, supplemented by (a) U-2 1:15,875 image types of special interest areas, and (b) periodic ERTS-1 imagery for use in monitoring general land condition change over a regional area. Conventional larger scale imagery and supplemental data could be integrated with the above combination as required to meet management objectives.

Additional Work Remaining to be Done.

1. Intervisibility analysis by automatic discriminatory means for: (a) Orick Corridor, (b) Redwood Creek Trail, (c) Bald Hills Road--U.S. 101 to south park boundary, and (d) Lady Bird Johnson Grove--towards Skunk Cabbage Creek.

OBJECTIVE: Produce a map showing those areas seen from selected points along a designated travel route, as developed from space imagery and/or the U-2 flights.

2. Stand stress analysis of the Tall Trees Grove through thermal imagery by controls at: (a) Prairie Creek State Park, (b) Jedediah Smith State Park, (c) Del Norte Coast Redwoods State Park, and (d) Redwood National Park "bulge" in Redwood Creek.

OBJECTIVE: Analyze condition and trend of vigor of the Tall Trees as compared to similar groves elsewhere to determine the effect if any of land use practices on areas near or adjacent to the Tall Trees.

3. Determination of areas of potential or actual soil mass movement anywhere in the Redwood Creek hydrologic unit on a base line and annual basis through automatic discriminatory analysis.

4. Automatic discriminatory analysis of lower Redwood Creek on a site-specific basis.

5. Quantitative logging debris sampling by logging systems and map delineation.

Accomplishment of these goals is dependent upon adequate funding by the National Park Service since no moneys have been allocated by it for any of the work accomplished so far by this Cooperative Agreement.

A final report was prepared:
Thomas, R. W. 1973. Preliminary study of the application of remote sensing data to inventory and monitoring of resources within and adjacent to Redwood National Park. Space Sciences Laboratory, University of California (Chapter 4 of the *Integrated Study of Earth Resources in the State of California Based on ERTS-1 and Supporting Aircraft Data*, Progress Report of 31 July 1973 (NASA Contract No. NAS 5-21827).

# # #

AN ECOLOGICAL SURVEY OF THE INTERTIDAL AND SUBTIDAL (MARINE) RESOURCES OF REDWOOD NATIONAL PARK

REDW-N-5

INVESTIGATOR: Milton J. Boyd
Humboldt State University

SUMMARY OF PROGRESS: During the past 6 months we have accumulated data on the following aspects of the coastal survey.

1. Measurements of water surface temperature, salinity, and chlorophyll concentrations have been completed at five sites along the coast of Redwood National Park.

2. Algae species have been collected and identified from two rocky intertidal locations. We have recognized 81 macroscopic algae species.

3. Photographic stations of approximately 1/10 m^2 size have been established at three intertidal locations. The stations include low, mid, and high intertidal locations. Measureable growth rates, mortality, and settlement of both plants and animals have been observed using this technique.

4. Line transects are being surveyed at three rocky intertidal locations. Preliminary analysis of the monthly transect data indicates substantial seasonal patterns of algal growth and abundance. Also, patterns of intertidal zonation are being analyzed via computer ordination of the transect data.

5. Thirteen species of intertidal fish were collected in two rocky intertidal locations. Two of these species are somewhat uncommon in other locations along the California coast and probably reflect inadequate collections in northern California. Numerous juvenile black rockfish were encountered, indicating the importance of intertidal habitats as nursery areas for this species.

6. Three sand beaches within the park are being studied to indicate interactions between physical processes (sand transport, wave action) and populations of organisms. A diverse fauna is associated with these beaches. Ten sand-dwelling crustacean species, five annelid polychaete species, and one bivalve mollusc have been identified. Seasonal variations in sand transport and the occurrence of organisms are being monitored by detailed monthly studies of substrate composition and beach profiles.

7. Four man-days of SCUBA diving off the coast of the park have been completed. Much of the bottom off both rocky and sandy portions of the coast is composed of coarse, rapidly shifting sand. On near-shore rocks, the attached fauna and flora are severely battered by wave action and floating debris. These subtidal areas do not support a highly diverse marine biota.

This study will characterize the importance of common intertidal species in ecological communities along the coast of Redwood National Park. Some information will be available about the seasonal dynamics of commonly ocçurring plants and animals. A major deficiency of the study is that little information on year-to-year variations in species composition or dynamics will be available. It would be advisable to consider extending the study to cover at most an additional year, or possibly a significant portion of an additional year (perhaps 3-6 months).

# # #

DYNAMICS OF PRAIRIE VEGETATION

REDW-N-9

INVESTIGATOR: Stephen D. Veirs, Jr.
Redwood National Park

SUMMARY OF PROGRESS: Permanent 200-ft transects were established in prairie (coastal grassland) vegetation within the park which has been recently released from domestic grazing. These areas were "prairies" at the time of arrival in the region of whites, based on the journals of Jedediah S. Smith (1828) and early survey records (1853). Since 1952 they have been grazed by domestic livestock with pasture grasses and other agresṣive exotic plants replacing the native vegetation. A voucher plant collection was prepared for the sampled areas and is now included in the park herbarium. Additional plots will be established this spring and repetitive determinations made to record change occurring in the prairies following removal of grazing.

A preliminary review of available sources suggest that after cessation of grazing by domestic animals, haying, and, occasionally, cultivation, the coastal prairies' herbaceous vegetation may be replaced in some cases by seral *Alnus rubra* later to be dominated by *Picea sitchensis*. In other instances it may be replaced by northern coastal scrub. These "prairies" may have been maintained as such by the native Indian people of the region through the use of fire.

Experimental work will be conducted to determine the historical role of fire in this vegetation, its influence in replacing the exotic grasses with native species, and in reversing the forest succession. Experimental work will be designed with a view to evaluating the use of fire as a management tool.

# # #

ECOLOGY OF THE COAST REDWOOD

REDW-N-1

INVESTIGATOR: Stephen D. Veirs, Jr.
Redwood National Park

SUMMARY OF PROGRESS: During 1974, work was begun on four additional 1-ha (2.47 acres) plots subjectively located in redwood vegetation on private lands in the Redwood Creek drainage near Orick, California. One of these was subsequently clear cut, the others will be harvested later. The understory vegetation of these plots was sampled destructively for age, height, stem diameter, and number of individuals for all woody species present. Overstory trees which were felled were aged and fire scars dated where present. The dominant canopy trees were redwood (*Sequoia sempervirens*) and Douglas fir (*Pseudotsuga menziesii*). The redwood ages were surprisingly great, one tree near the plot was more than 1604 years of age, those on the plot were 1470+, 1243, 1130+, 1110, 824, 789, 765, 735, 700, 640, 430, and 170 years. Douglas fir ages were 570, 558, 531, and 334 years. *Tsuga heterophylla* (hemlock), *Abies grandis* (grand fir) and *Lithocarpus densiflorus* (tan-oak) dominated the sub-canopy and understory, all three species were well represented in all age classes from seedlings to maximum ages of 325, 216, and 120 respectively. *Vaccinium ovatum* (huckleberry) exceeding 50 years and *Rhododendron macrophyllum* more than 120 years old were found in the understory-shrub layers. Young Douglas fir and redwood were almost completely lacking, disregarding redwood sprouts on dominant stems. A few redwood and Douglas fir seedlings were found on logs and root wads. Evidence of fire was present, but few trees were scarred and no fire frequency is yet determined. Data collection from the plot presently continues.

Tan-oak appears the most successful understory species, maintaining the greatest growth rate (diameter) of all other woody species to its maximum size, as determined by linear regression analysis ($r^2 = 0.79$) on this southwest facing slope (elevation 600-800 ft). On a nearby northwest facing slope at the same elevation tan-oak displayed the same diameter growth rate ($r^2 = 0.83$).

In terms of growth in diameter, tan-oak significantly out-performs the understory conifers. On the second plot, redwood, grand fir, and hemlock are well represented in the understory but Douglas fir is absent. Regression lines computed for redwood, hemlock, and grand fir understory trees suggest that their growth rates are well below the rates of canopy trees of the same species, although the data for canopy trees on this plot has not yet been obtained. This would suggest some change in the understory growing conditions, perhaps in understory light intensity as mediated by the canopy.

Recent fire frequency is low on both plots if one uses the sensitive hemlock and tan-oak as indicators. The absence of tan-oak greater than 120 years, which corresponds with the arrival of whites in this region, cannot be considered significant as older stems of this species are usually rotten at the base and eventually mechanical failure claims the tree. Tan-oak sprouts from a bud collar following breakage as above or fire. It also reproduces successfully from seed in the duff. Grand fir reproduces successfully from seed in the duff also. Hemlock is commonly limited to a substrate of moist logs, woody debris, cradle mounds and root wads, as is redwood, which is less successful than hemlock. Redwood appears to be extremely persistent as an understory tree. Established seedlings may die back or be knocked down and sprout again from the bud collar in several pseudo generations, persisting for decades on a minimal energy budget. These trees may subsequently enter the canopy rapidly should a favorable opening appear there.

A good deal of work remains to be done on plots established to date. I expect to summarize data obtained through the next year for publication. It will represent a first good look at the dynamics of natural redwood vegetation.

# # #

ROCKY MOUNTAIN NATIONAL PARK

FIRE ECOLOGY IN HIGH ELEVATION FORESTS IN COLORADO

INVESTIGATORS:
E. W. Mogren)
Jack S. Barrows) Colorado State University
Harry B. Clagg, Colorado State University and National Park Service

SUMMARY OF PROGRESS: Field work has been completed and data analyses are being carried out. Fire history research is still in progress (mid 1800s to 1915). Peak vegetation species diversity occurs between 8 and 15 years after occurrence of fire in lodgepole pine and spruce-fir forests. Average periodicity of 15-20 years between Class C or larger fires on the east side of the park between 1600 and 1870.

Future research needs include: (1) More detailed fire history studies; (2) Continued study of vegetation succession after disturbance; (3) Continued study of active fires; and (4) Improve basic resource inventory.

Publication

Fire Management in Rocky Mountain National Park. *In* Tall Timbers Fire Ecology Conference Proceedings 1974. (In Press) (Co-authors David Butts, David Stevens).

# # #

PREPARATION OF BOOK, FOREST TREES OF COLORADO

INVESTIGATOR:
Gilbert H. Fechner
Colorado State University

SUMMARY OF PROGRESS: Field collections nearly completed; all collections within park boundaries completed. Study is descriptive of native tree species. Work should proceed as planned. However, completion date should be extended to complete revisions and photographic duplication.

# # #

BIRD BANDING RESEARCH

INVESTIGATORS:
Allegra Collister, Denver Museum of Natural History
Richard Esposito, Colorado Division of Wildlife

SUMMARY OF PROGRESS: First phase of project completed with publication by Denver Museum of Natural History in June 1970 of "Birds of Rocky Mountain National Park."

Present research aimed at providing material for a complete field guide to birds of the park and adjacent area, oriented towards the beginning and amateur naturalist. In the belief that most visitors to the park fall into this category, we are working on a guide that will facilitate identification of bird species, thus enhancing the total park experience.

During 1974, bird banding in the park and adjacent region has continued, with 130 birds of 25 species mist-netted and banded. List will be placed on file in library at Administration Building in RMNP.

Richard Esposito, sponsored by Colorado Division of Wildlife, and banding on a subpermit under my federal permit #6549, is continuing his study of accipiters in this region.

# # #

RECOVERY OF ALPINE TUNDRA SYSTEMS FOLLOWING HUMAN TRAMPLING

INVESTIGATORS: Beatrice E. Willard, Member, Council on Environmental Quality and University of Colorado, Boulder
William Reid, University of Colorado, Boulder

SUMMARY OF PROGRESS: The investigators are preparing a paper on the first 15 years of data--1959-74. This will describe trends and provide statistical analysis of them. The data are already stored in the computer at University of Colorado, Boulder. Annual observations reemphasize the slowness of recovery that *Kobresia* turf fellfield ecosystems experience following protection from trampling by visitors. The extension to the fellfield exclosure at Forest Canyon Overlook is in its fourth phase of succession following 2 years of intensive trampling, then protection for 13 years. This phase is nothing like the original system, so it can be anticipated that more phases are to come. Plants in parts of the Rock Cut Exclosure continue to die out for a variety of reasons. This is slowing the recovery processes there. As observations of these exclosures continue, the knowledge gained accentuates the long-range value of maintaining the exclosures and of observing them periodically. To date, no other similar experiments are known to be underway in Rocky Mountain tundra. The more substantial fencing installed by the National Park Service in 1973 is proving most helpful. It is essential that the purpose and value of these installations be well known and understood through the park staff, as well as the regional and national offices.

# # #

GEOMORPHOLOGY FIELD CAMP

INVESTIGATOR: W. C. Mahaney
York University, Ontario, Canada

SUMMARY OF PROGRESS: During the 1974 summer field season my work in the Colorado Front Range was directed towards a study of Quaternary deposits and soils in the St. Vrain drainage (Ward Quadrangle). Most of this research will be published jointly with B. D. Fahey, R. F. Madole, and S. E. White, the bulk of the field work being carried out in conjunction with students in my Rocky Mountain Geomorphology course. My work in Rocky Mountain National Park was more in the form of a reconnaissance and was directed primarily at acquainting students with the late-Quaternary deposits, soils, vegetation, lithology, and environmental history. Our activities in the park were confined to a 2-day reconnaissance on the Pinedale and Bull Lake moraines in the vicinity of the Big Thompson River (Longs Peak Quadrangle), including an examination of soil profiles on roadcuts and investigation of the nature of surface materials. We also visited the area around Milner Pass which provides an excellent opportunity to observe patterned ground features, erosion surfaces, nivation processes, mass wasting, and treeline phenomena. This reconnaissance allowed a preliminary overview which assisted immensely with later work in the St. Vrain Drainage Basin.

# # #

AQUATIC RESOURCE SURVEY
ROMO-N-02a

INVESTIGATORS: D. R. Stvenes
James Mullan

OBJECTIVES: 1. To classify and describe aquatic ecosystems of the park.

2. To determine degree of natural production in lakes previously artifically stocked.

3. To monitor fisherman pressure, harvest, and impact on surrounding ecosystems.

4. To recommend management action.

METHODS: 1. Sample lakes by gill net to determine species, sex, and age composition of populations.

2. Monitor stream populations by electrofishing and tagging.

3. Conduct voluntary creel census to measure pressure and harvest.

RESULTS AND DISCUSSION: Lake Surveys. Three lakes were surveyed in 1974, all of which were on the most recent stocking schedule.

Lake-of-the-Clouds was surveyed on 8-9 July. A large population of native cutthroat trout is present. Two gill nets were set overnight and a total of 41 fish were caught. The mean length for females was 14.2 (11.3-16.5). For males it was 12.5 (10.5-14.0). Although stream spawning areas are very limited, the fish were attempting to spawn on shallow sandy sites along the shore. The last stocking was in 1968 with 2500 cutthroat fry. Some of the present population may still be from this stocking but it appears that some natural reproduction is present.

Timber Lake was surveyed on 10-11 August with two gill nets set overnight. No feeding activity or fish swimming near shore was observed. A total of 12 cutthroat trout were caught. Females had a mean length of 11.1 (6.1-15.5) and males 8.4 (4.6-13.0). Food in stomachs appeared to be complete. There is one good outlet stream and several small inlets that probably furnish sufficient spawning area. Natural spawning appears to be sufficient to meet needs.

Thunder Lake was surveyed on 24-25 July with two gill nets, also. Altogether a total of 36 fish were caught, 15 brook trout, and 21 cutthroat. Brook trout females had a mean length of 11.3 (9.1-14.2) and males 10.4 (8.6-11.5). Cutthroat females had a mean length of 11.1 (6.0-16.5) and males 12.6 (9.6-17.5). Natural reproduction is present.

Scales were collected from all fish to use in determining age. Since this data is not presently available, it will be reported later. The ages will be of value to assess the natural reproduction present, especially in Lake-of-the-Clouds.

Stream Surveys. Acting on an old report of the presence of cutthroat trout, the headwaters of the North Fork of the Colorado River above Lulu City was surveyed. It was hoped that a population of Colorado River cutthroat (*Salmo clarki pleuriticus*) could be located. The stream was surveyed to about 1.5 miles above the townsite. The only fish species found was brook trout.

In 1973 a total of 182 fish were tagged in the Colorado River, North Inlet and Onahu Creek. The objective of this project is to obtain more information on the angling pressure and movement or ranges of these fish. The fish were caught by electrofishing and tagged by inserting a nylon "spaghetti" tag with a T-bar anchor just below the dorsal fin. Only one of the tagged fish was returned by an angler in 1974. The reasons for the failure, whether the result of mortality of the tagged fish or not enough fishing pressure, was not determined.

On 16 and 17 October 1974, another 419 fish were tagged, primarily in the Colorado River but also in Onahu Creek and Beaver Creek. An attempt will be made to get a better return this year.

Creel Census. In 1974 the creel census reverted to giving the postcard forms out to potential fishermen and requesting their return when fishing was completed. Most of the surveys in the last 5 years have been by using volunteer researchers actually questioning the fisherman. The technique used this year was completely unsatisfactory and will not be used again. Only 65 cards were returned, almost no cards from unsuccessful fishermen, and many with obvious errors in identification of fish. The value of the data obtained is questionable.

PLANS FOR 1975: 1. Lake surveys will continue, with Fern Lake, Odessa Lake, Ouzel Lake, and Pear Lake scheduled for survey.

2. Baker Creek will be surveyed for the presence of Colorado River cutthroat.

3. Creel census will concentrate on the Colorado River but by using a volunteer researcher.

# # #

GREENBACK RESTORATION STUDY
ROMO-N-20

INVESTIGATORS: David R. Stevens
James Mullan

OBJECTIVES: 1. To develop a technique for removing exotic fish, primarily brook trout, from stream-beaver pond complexes on east slope of park.

2. To reestablish pure greenback trout in several accessible drainages for demonstration purposes, provide transplanting stock, and aid in removing the greenback from endangered status.

3. To determine feasibility of restoration of greenback into other native habitats.

METHODS: 1. Survey Hidden Valley Creek by electroshocker to determine success of restoration effort.

2. Check lower Hidden Valley Creek with Rotenone to determine reinvasion by brook trout.

3. Survey east slope streams and beaver pond complexes to locate other sites for restoration.

RESULTS AND DISCUSSION: On 15 October a survey was made of Hidden Valley Creek to check survival and reproduction in the greenback population. A battery pack shocker was used.

A 100-yard section was checked above the main beaver pond area. No fish were found. Below the largest beaver pond, four adult greenback were located. Near the old maintenance shed location, two more adults and two fry were found. The fry were identified as greenback by J. Mullan.

No brook trout were found in the creek. A small amount of Rotenone fish toxicant was put into the stream where it outlets from Hidden Valley. No dead fish were found above the Little Horseshoe bridge. Brook trout were found about 200 yards below the bridge.

It appears that the greenback have survived and reproduced the first year. The project is considered a success at this time.

PLANS FOR 1975:

1. Locate another test site for treatment and restoration of greenback.
2. Continue to monitor Hidden Valley Creek.

# # #

UNGULATE ECOLOGY STUDIES

ROMO-N-13

INVESTIGATOR: David R. Stevens

OBJECTIVES: 1. To determine the year around distribution, habitat use, and food habits of elk and deer in Rocky Mountain National Park.

2. To obtain quantitative data on population dynamics of the two species.

3. To obtain data on other ecological relationships.

4. To provide data for management of these species and their habitats.

METHODS: 1. Determine distribution, habitat use, and food habits through (a) periodic field observation trips to record location, activity, vegetation type, exposure, weather conditions and other pertinent data on animals observed, (b) aerial observations by helicopter as often as feasible to supplement ground observations, (c) observe feeding animals and examine feeding sites for plant use, and (d) collect rumen samples from any accidentally killed or poached animals and analyze for food habit data.

2. Determine population characteristics by (a) recording sex and age classification from aerial and ground observations, (b) trend counts of population numbers, and (c) observation of winter mortality.

3. Study ecology of species through (a) integration of data collected under vegetation and winter habitat studies, (b) direct observation of intraspecific relationships, and (c) direct observation of animal behavior.

RESULTS: Field work on this study continued but at a reduced level. Data was gathered primarily to fill gaps in the life histories of the two ungulates. Considerable time was spent compiling data with the goal of producing a comprehensive final report this year.

Range use and activity data was collected on 3977 elk observed in 159 groups during the period. Food habits data was observed on 16 sites with 1667 instances of use being recorded on spring and summer ranges. One helicopter trend count was made in February, recording 516 elk within the park boundaries. Of these, 103 were found on the alpine winter range. The Colorado Division of Wildlife counted 366 elk east of the park at about the same time.

Reproduction in the elk population appeared to increase according to ground classifications. The calf:cow ratio was 40:100 compared to 18:100 in 1973. The composition of the herd was determined to be 9% adult males, 6% yearling males, 61% females and 24% calves.

Hunting season outside the park was held in October in 1973, with no late season. A total of 91 elk was killed, 60 of which were males. The post season in both 1973 and 1974 was canceled due to weather conditions not being severe enough to force migration outside the park. Results of the regular season ln 1974 are not available. Again 400 licenses were provided with 300 specified for males and 100 females.

Data was also gathered on 684 deer in 179 groups. Food habit data were collected at 17 feeding sites with 1464 instances of use recorded. The deer population remains fairly low. Reproduction, however, appears to be increasing, with a fawn:doe ratio of 48:100 compared to 23:100 in 1973. The population composition was indicated to be 14% males, 6% yearling males, 53% does, and 26% fawns in October and November 1974. The hunter harvest outside the park was 510 antlered deer in 1973. The 1974 season was also antlered only, with no results available.

PLANS FOR 1975:

1. Summer range use and food habits data will be gathered for both species.
2. The comprehensive final report will be prepared.

# # #

ECOLOGY AND EPIDEMIOLOGY OF VECTOR-BORNE DISEASES IN THE ROCKY MOUNTAIN NATIONAL PARK

INVESTIGATORS:

Robert G. McLean)
G. Stephen Bowen)
Allan M. Barnes) Department of Health, Education and Welfare
D. Bruce Francy)

SUMMARY OF PROGRESS: A total of 2500 mammals of 21 species (mostly rodents) were trapped at eight different locations at various altitudes on the eastern slope of the mountains. The animals were bled, examined, marked, and released and the blood and ectoparasites from approximately 1800 animals are being tested in our laboratories for various vector-borne diseases (such as Colorado tick fever (CTF), plague, California encephalitis, and others). CTF virus was isolated from the blood of most of the rodent species and the snowshoe hare as well as from ticks taken from animals and collected from the ground. The virus was recovered from the five trapping locations below 10,000 ft but not from the three locations above this altitude. The locations (two) with the greatest prevalence in rodents and ticks were in the Moraine Park area. Plague was also isolated from rodent fleas from these same two locations and antibodies in carnivores were also found. Because of the preponderance of disease in the Moraine Park area, a detailed study of rodents utilizing grid-type trapping is planned in this area and in an ecologically comparable area to investigate the dynamics of these diseases. Also, since a large campground is located within this focal area, intensive monitoring of these animal populations is planned as well as periodic monitoring of animals in the smaller campgrounds, including those on the western slope. More intensive trapping of the carnivore population and sampling of the deer and elk populations is also planned to investigate their role in the ecology of these diseases.

# # #

U.S. GEOLOGICAL SURVEY; GEOLOGY OF ROCKY MOUNTAIN NATIONAL PARK

INVESTIGATORS: William A. Braddock)
James C. Cole) U. S. Geological Survey and University of Colorado
John M. O'Neill)

SUMMARY OF PROGRESS: During the summer of 1974, Mike O'Neill completed mapping of the Never Summer Mountains extending from the North Fork of the Colorado westward across continental divide into North Park as far south as Baker Gulch. The results of this part of the study will be available in Mike's Ph.D. thesis in July 1975. Jim Cole completed final field observations in the area bounded by Odessa Gorge-Big Thompson River on the north; continental divide on the west; North Ridge-Sandbeach Lake on the south. He will also be completing his Ph.D. thesis by July 1975. William Braddock mapped the region north of Trail Ridge and west of Mummy Mountain.

It is anticipated that Braddock will complete the region north of Forest Canyon-Big Thompson and possibly parts of the Gorge Lakes-Hayden gorge area during the summer of 1975. It is also probable that a C.U. Master's thesis will be started in the area north and south of Grand Lake (to extend the work done by David Abbott of the Colorado School of Mines).

Many interesting geologic features have been studied within the part of the park which we have now mapped. These features include large folds of Precambrian age, large faults of Precambrian and Younger age, intrusive and extrusive igneous rocks, and evidence for a large ice mass during Pleistocene in the northwest part of the park. Discussion of these features without reference to the geologic map would be confusing and will not be attempted in this report. Braddock will provide a copy of the mapping completed to date to the Superintendent in June 1975, and will be available in Estes Park during June to discuss the geology with National Park Service personnel.

# # #

ECOLOGY AND POPULATION DYNAMICS OF WHITE-TAILED PTARMIGAN

INVESTIGATOR: Clait E. Braun
Colorado Division of Wildlife

SUMMARY OF PROGRESS: Results of some aspects of the study have been published in technical articles and a technical bulletin. Copies of all published papers resulting from the studies in Rocky Mountain National Park have been deposited in the park's library. Major objectives in 1974 were similar to those of previous years: (1) document, through banding and reobservation, fluctuations in populations of ptarmigan on the study sites adjacent to Trail Ridge Road; (2) assess the impact of June weather conditions upon nesting success and production. In 1974, 71 ptarmigan were newly banded including 44 young of the year and 20 yearlings (birds hatched in 1973). An additional 48 birds previously banded (as early as 1966) were either recaptured or reobserved. This number is higher (+12 birds) than in either 1972 or 1973 and indicates improved survival from 1973 to 1974. Thus, mortality rates stabilized in 1972-73 and decreased in 1973-74. Breeding densities in the spring of 1974 were only slightly lower than in 1973, but were the lowest observed during the 9 years. Nesting success and production in 1974 were good to excellent, with chick survival to 1 September rated as good. It is expected that breeding densities in the spring of 1975 will increase significantly, possibly equalizing levels observed from 1966 to 1969.

Facilities usable for alpine research in Rocky Mountain National Park are now nonexistent with the removal of the Rock Cabin Ranger Station. It is difficult to see how continuous research in alpine areas can be maintained in the park in the future.

RESPONSES OF ELK TO HUMAN DISTURBANCE DURING FALL AND WINTER

INVESTIGATORS: Richard D. Schultz) Colorado State University
James A. Bailey)

SUMMARY OF PROGRESS: The field work associated with rutting elk was completed on 29 October 1974. We are now analyzing these data and preparing a progress report which is due 1 February 1975. A study plan for the winter portion of this investigation is also being developed.

From preliminary analysis of the data, it appears the level of human disturbance had little or no effect upon the bugling rates of rutting bull elk in Horseshoe Park or in Endovalley. Factors appearing to stifle elk bugling and/or bugling audibility were rain, snow, fog, wind speed, and wind direction.

Levels of human disturbance do not seem to significantly affect the number of elk seen on the large meadow of Horseshoe Park. However, human activity off established roadways such as hiking, photography, and elk observing can result in disruption of normal behavior and in premature departure of elk from the viewing area.

Analysis of the rutting-season data will be completed in the future. Additional factors to be examined include quantifying human activity and characterizing elk movements on and off the large, open meadow of Horseshoe Park.

Winter investigations will attempt to quantify elk reactions to individuals as well as to large groups of people. We may also examine responses of elk to the use of spotlights in both Morraine Park and Horseshoe Park.

A final report will be prepared and submitted by 1 August 1975.

# # #

THE COMPOSITION AND DYNAMICS OF THE FORESTS OF THE EAST SLOPE OF THE COLORADO FRONT RANGE

INVESTIGATOR: Robert K. Peet
Cornell University

SUMMARY OF PROGRESS: The field work portion of the project is now complete, though a short visit of 1-3 weeks may become necessary during the next summer or two to fill voids discovered in the data.

The analysis of the forest vegetational composition should be completed by February 1975. The analysis of the forests dynamics project should be completed in August 1975, though additional work with mathematical modeling based on this data can be expected to continue for an additional year or two.

A copy of my thesis will be sent upon completion, August 1975. Also, four bound volumes of data (approximately 1000 pages) constituting the data base for the project will be sent.

A recent paper, "The measurement of diversity" was published in Annual Review of Ecology and Systematics 5:285-307.

A collection of approximately 800 specimens of vascular plants collected in the park as vouchers for the project has been donated to the park with the understanding that they will be retained and curated.

FIELD OBSERVATION OF RED-TAILED HAWKS; COLORADO REGION

INVESTIGATOR: Katherine M. Suhrbier

SUMMARY OF PROGRESS: This project is a field observation study of a mated pair of Red-tailed Hawks which were banded in 1965 in the Mississippi River Valley of Wisconsin. There was no recorded hatch in their Wisconsin nesting area prior to their westward migration, but they have nested and reproduced in Rocky Mountain National Park for the past 5 years. Of the nine birds produced during this period, five have survived to date. All young from the original nest are being studied in this program and their nesting activity recorded.

Findings from my field observations will be correlated with research on the nesting habits of raptors being carried out in Wisconsin and Illinois. The data is also being used in behavioral studies on the effect of habitat and time zone changes on basic living patterns.

We hope to continue our field observations for 3 years if funding permits and are considering an expansion of our banding program to include other raptors within park boundaries during May 1975.

# # #

PASSERINE BIRDS, PARTICULARLY HORNED LARKS, MAINLY IN ALPINE TUNDRA AREAS

INVESTIGATOR: Ronald A. Ryder
Colorado State University

SUMMARY OF PROGRESS: Emphasis continues to be mainly outside Rocky Mountain National Park but limited data on nest establishment and times of occurrence in the park were obtained during Natl. Wildl. Fed. Conservation Summits in June and December.

Limited field work will again be conducted in the park in 1975, primarily in conjunction with the Conservation Summit at which times I would particularly like to be able to band.

# # #

COMPARATIVE BEHAVIOR OF TWO FORMS OF ROSY FINCH (*LEUCOSTICTES*)

INVESTIGATOR: Daniel F. Shreeve
Cornell University

SUMMARY OF PROGRESS: Display and related breeding behavior have now been closely observed in both the Brown-capped form and Aleutian Island form of the genus *Leucosticte*.

Since April 1974, research has concentrated on the effects of disparate sex ratio on breeding and foraging behavior. Sex ratio of adult Rosy Finches on Adak Island is approximately 3.2:1.

A study of mortality is now in progress on Adak Island, in cooperation with the Aleutian

Islands National Wildlife Refuge. The non-migrant Rosy Finch population here began to be banded in 1969, but much larger numbers were banded during research in the summer of 1974 for this study. The principal objective at present is to determine the period of excess female mortality.

A final observation of breeding behavior on Adak Island is planned for the spring of 1975, using birds identified with color bands.

One final observation is planned of breeding activity on Iceberg Cliff, Rocky Mountain National Park. This brief observation of about 1 month from 1 July is considered important, principally to improve recordings of vocal displays which appear to be different in the two forms and to confirm or dispute some hypotheses regarding breeding behavior which have been partially established from previous research.

Present plans are to organize data and submit the thesis for this work during the winter of 1975.

# # #

ECOLOGY AND BEHAVIOR OF THE WILLIAMSON SAPSUCKER

INVESTIGATOR: Allen B. Crockett
University of Colorado

SUMMARY OF PROGRESS: In 1974, I located additional nests of both Williamson and Yellow-bellied Sapsuckers, and I color-banded several additional pairs of each, including nestlings. I also recorded various nest, tree, and stand parameters--e.g., direction of hole orientation, height of hole, condition of tree, size and density of stand, etc.

My thesis is completed, one article is in press, and other articles will soon follow. I have extended the study in order to gather additional information on pair-, nest-, and territory-fidelity of marked Sapsuckers.

# # #

PREDATOR-PREY AND NICHE RELATIONSHIPS AMONG FIVE INSECTIVOROUS BIRDS IN A MONTANE FLOODPLAIN

INVESTIGATOR: Robert C. Eckhardt
Cornell University

SUMMARY OF PROGRESS: During the months of May, June, July, and August 1974, we spent 544 person-hours in the field. A short preliminary period was spent in resurveying the study area, according to a new map I had drawn up the previous winter, and in netting and banding birds as they arrived and took up residence. The remainder of the summer was spent in concurrent investigations of the following: (1) collection by four different methods and preliminary analysis of the available insect prey in the study area; (2) delineation of the breeding territories of all resident insectivorous birds of the willow and willow-pine ecotone; (3) detailed analysis of predatory behavior and time budgets exhibited by the birds; and (4) on nearby National Forest lands, collection of stomach contents for analysis of prey captured.

Spring 1974 came earlier and was milder than that of 1973. Dusky Flycatchers were already present and setting up territories when I arrived in late May. No other species had arrived in any significant numbers when, in early June, we received a heavy snowfall that remained on the ground for 3 days and longer. There was heavy mortality among thrushes and other ground-birds, and all Dusky Flycatchers in the study area disappeared during this period. No Dusky Flycatchers took up residence in the following weeks. Shortly after the storm, we were studying the following insectivorous birds breeding within the study area: 27 pairs of Wilson's Warblers (26 pairs in 1973); two pairs of Yellow Warblers (4); three pairs of Yellow-throats (2); 5 pairs of Willow Flycatchers (5); and 5 pairs of Western Wood Pewees (6). Of the birds banded in 1973, nine returned to breed in 1974, all of which were Wilson's Warblers. (This represents a 50% return of the marked breeding Wilson's Warblers.)

It quickly became apparent that Flycatcher populations, at least, are quite dependent upon weather and perhaps other stochastic variables in the area. Dusky Flycatchers were completely eliminated in the study area by the June snowstorm, and no more arrived in subsequent weeks to take their place. Willow flycatchers nested at the same density as last year in the study area, either due to a lack of individuals to move in where Dusky Flycatchers once had been, or to an inability to do so. However, in other areas of similar habitat (and of similar bird composition in 1973) in nearby Forest Service lands, Dusky Flycatchers were present and often abundant, while in a few instances Willow Flycatchers were rare or absent. Thus, in Flycatcher populations, stochastic, density independent variables can have a dramatic effect on local populations.

Breeding territories exhibited the same basic relationships in 1974 as in 1973. Wilson's Warblers set up territories without regard to other species, while Yellow Warblers and Yellowthroats maintained mutually exclusive areas. Willow Flycatcher territories were of similar size to last year's. Of the 1973-banded Wilson's Warblers which returned in 1974, some held territories in the same areas as those of the year before, while others set up territories in different parts of the study area. More detialed data on Pewees and Willow Flycatchers in 1974 will allow analysis of shifting territories in the near future.

Preliminary study suggests that the Willow Flycatcher, in the absence of the Dusky Flycatcher, extends its foraging range and broadens its foraging behavior. Pewees and Warblers, behaving in circumstances similar to 1973, showed foraging characteristics similar to that year. Within both of the two guilds (Warblers, or searchers, and Flycatchers, or pursuers), we can now identify two subgroups. The first is those whose habits restrict them to the willow thickets almost entirely. Included here are Wilson's Warblers and Yellowthroats, and Willow Flycatchers. The second subgroup includes those species which can be found with some frequency in both willow thicket and along the lodgepole ecotone. These include the Yellow Warbler and the Western Wood Pewee.

During my final field season of 1975, I plan to work at elucidating the interplay of functional groups (guilds) and compare the structures of individual guilds. With further work, and the analysis of work by others on other species, I hope also to investigate further the role of searchers and pursuers in predator-prey relationships.

# # #

GLACIAL GEOLOGY OF THE WEST SLOPE OF ROCKY MOUNTAIN NATIONAL PARK

INVESTIGATOR: Thomas C. Meierding
University of Colorado

SUMMARY OF PROGRESS: During the summer of 1974, additional weathering data was collected, primarily from the Granby gravel terraces and the glacial moraines of the Monarch Valley in Shadow Mountain Recreation area. All data collected thus far have been analyzed, and a reasonably clear picture of the Pleistocene glacial history of the upper Colorado River Basin has emerged. There are still major gaps in the story which hopefully will be filled with one more summer of field work. This work will be similar to that performed in the past. Most of the sampling work will be performed outside the park but a few more samples will be collected from the Tonahutu Creek area and Monarch Valley.

On the basis of data obtained thus far, a tentative draft of the Ph.D. dissertation will be completed during the spring, and the final draft will be written in the fall of 1975 after the summer field data becomes available. The emphasis of the study has changed slightly in that I am now concerned more with an evaluation of the usefulness of the various age-dating criteria than on the history of glaciation itself, but the dissertation will still contain such a history and a map of the glacial and fluvioglacial deposits.

# # #

INVESTIGATIONS OF VOLCANIC ROCKS IN COLORADO

INVESTIGATORS: W. N. Sharp) U. S. Geological Survey
R. B. Taylor)

SUMMARY OF PROGRESS: Specimens of rhyolitic rocks were collected from several levels on Specimen Mountain in October 1973. These rocks are welded rhyolitic volcanic ash flow and ash flow breccia, and formed close enough to the volcanic vent site to be lithsophysal in character. Out-gassing of the partially melted rock continued after its deposition--as flow layers or vent-filling. In-vent and near-vent rhyolitic volcanic rocks not uncommonly develop gas cavities in the highly viscous material and have an assemblage of minerals associated with these gas cavities. The mineral assemblage in general, and the possible presence of garnet associated with this out-gassing, was of particular interest. An earlier study of Specimen Mountain rocks by Wahlstrom would be augmented by our reassessment.

Gas-phase minerals of the Specimen Mountain rocks include quartz, topaz, sanidine, hematite, and sparse manganese oxides, as reported by Wahlstrom. We found no garnet in the assemblage. Some garnets are present in the rock mass but these are present as fragments picked up by the magma flowing through Precambrian crust.

Garnets can be a mineral component of similar vapor-phase assemblages. Manganese is a required component, and its oxidation state needs to be low in order for it to combine with silica, alumina, and iron to form garnet. The resulting garnet is spessertine, a type that can form at relatively low temperatures. If the oxidation state of the manganese in the melt is too high, manganese forms various exides instead of garnet. This is the siutation at Specimen Mountain. Very fine-grained biotite mica is one of the gas-phase minerals. The composition of the biotite shows very low values of magnesia, which is a strong indication that the activity of oxygen was at a high level. This biotite is in the compositional field of siderophyllite. This mineralogic data is one kind of information indicating that the volcanic vent for the Specimen Mountain ash flows and flow breccias was not at this specific site. The materials were oxidized somewhat--probably by air mixing--before accumulating.

Specimens of these rocks were also used to date this volcanic episode. Zircon crystals, a normal minor mineral found in rhyolitic rocks, were separated and dated by C. M. Naeser using the fission-track method. Within the precision of the method, the dating of the zircons commonly dates closely the venting and solidification of the magma. Rocks from Specimen Mountain and from road cuts west of Ice Berg Lake were dated at about 27 million years.

The rhyolitic rocks of Specimen Mountain appear to be a remnant of a late stage volcanic event associated with a large volcano of andesitic lineage which erupted complexly, and later collapsed. Specimen Mountain itself seems to be a part of a major ash flow erupted from this collapse caldera which was centered to the west. The Oligocene age of this activity suggests that it took place in a period of wide-spread volcanism throughout Colorado.

Investigations of Tertiary volcanic activity in Colorado by the U. S. Geological Survey are required as a part of our studies of volcanic petrogenesis, and assist energy and mineral resource evaluation; these will be reported in our regular publications. The geology of Rocky Mountain National Park is an important geologic element; the caldera west of Specimen Mountain is a major volcanic feature.

# # #

STUDY OF THE *CAREX* OF ROCKY MOUNTAIN NATIONAL PARK AND COLORADO

INVESTIGATOR: Miriam F. Colson

SUMMARY OF PROGRESS: My Polyclave Key to the species of *Carex* in Colorado and Wyoming is now completed. The decks are for sale at the University of Colorado Natural History Museum. The decks include an attribute card for Rocky Mountain National Park as well as for Colorado and Wyoming.

I am continuing my studies of *Carex* in Colorado and North America and will continue to send specimens to the park.

# # #

INTERSPECIFIC AGONISTIC BEHAVIORS IN GROUND SQUIRRELS (*SPERMOPHILUS*) AT ARTIFICIAL FEEDING STATIONS

INVESTIGATOR: David Byman
Colorado State University

SUMMARY OF PROGRESS: From 11 July to 6 September 1974, I live-trapped Richardson's (*Spermophilus richardsonii*) and golden-mantled (*S. lateralis*) ground squirrels in Moraine Park Campground of Rocky Mountain National Park. All trapping was restricted to campsites A-122, A-126, A-129, and A-130. A total of 12 different golden-mantled ground squirrels (6 males, 6 females) and 39 different Richardson's ground squirrels (23 males, 16 females) were captured, dyed, marked with an ear tag or toe clip, and released.

As the purpose of my project is to observe interspecific agonistic behaviors at artificial feeding stations, I periodically put one or two small piles of oats at easily observable locations within 15 m of the campsite that I was using. I categorized observed behaviors as escape, avoidance, tolerance, threat or chase. I wanted to determine if the Richardson's ground squirrel acts aggressively towards the golden-mantled ground squirrel and whether the larger Richardson's squirrel dominated the mantled squirrel in the interspecific encounters. I hope to be able to explain observed micro-distributions of these animals in the wild with the results of my observations at feeding stations.

Unfortunately, I observed far too few interspecific interactions to draw any conclusions of statistical validity. Therefore, I request permission to continue my studies in Moraine Park Campground during the spring and summer of 1975. I am very optimistic of getting lots of good data in May and June as ground squirrels breed and raise litters in those months and are far more aggressive than they are later in the year. I would like to use A-126 for my studies, as it is a relatively secluded campsite that is visited frequently by gouund squirrels of both species. I would like to begin trapping and observing animals on 15 April and finish on 15 September 1975.

# # #

INVESTIGATION OF THE BIOLOGY OF AQUATIC NAIDID OLIGOCHAETES, ESPECIALLY THOSE BELONGING TO THE GENUS *CHAETOGASTER*

INVESTIGATOR: Donald L. Elrick
University of Colorado

SUMMARY OF PROGRESS: The benthic invertebrate fauna of Colorado are poorly known, and no one has investigated aquatic oligochaetes other than as an adjunct to entomological studies. My reason for collecting *Chaetogaster*, a cosmopolitan genus, in Rocky Mountain National Park is to supplement observations from other montane and alpine sites.

Worms collected in the field are maintained in a growth chamber--those from last summer are still alive in either culture dishes or plastic bags. Below is a summary of collecting sites, dates, and significant or promising findings up to 9 December 1974:

Bear Lake. 7 July 1974. *Chaetogaster* cf. *langi* in detritus of tendipedid tube and inside hollow grass stems. Diatoms in gut (counted 19 in gut of a worm less than 1.0 mm long). Setal taxonomy aberrant.

Nymph Lake. 7 July 1974. This semidrainage lake has interesting fauna. Floating or loosely attached to the bottom were enormous donut-shaped colonies of the green ciliate *Ophrydium versatile*--park visitors commented on the "fresh-water jellyfishes." Although the bottom detritus revealed no oligochaetes, the ciliate colonies contained perhaps three species of *Chaetogaster*: *C.* cf. *langi*, with peculiar taxonomic features, *C. diastrophus*, and *C. crystallinus*. It is unusual to find all three species on the same substrate. I have found *Chaetogaster* associated with *Ophrydium* only in some ponds on Arapahoe Moraine. It has not been reported in the literature. A piece of wood from the lake had a tiny cocoon in a crack. Evidence of sexual activity in any naidid is rarely reported, especially from North America.

Emerald Lake and Glacier Creek. 7 July 1974. No oligochaetes found.

Poudre Lake. 24 August 1974. This lake is the highest in the state where I have found *Chaetogaster*. The worms resemble *C. langi*. One was on the pronotum of caddisfly larva, the others were in the bottom detritus.

Iceberg Lake. 24 August 1974. Bottom detritus contained abundant tiny metazoans but I found no oligochaetes.

I feel that the taxonomy of the genus *Chaetogaster* must be revised; the worms collected from Nymph Lake may be valuable in this regard. In addition, collecting in the park has confirmed or broadened observations made elsewhere concerning the biology of this genus. Because my research is incomplete this report may seem scanty. There is still much laboratory work to do. I will be glad to furnish any forthcoming pertinent information. I do feel that the waters of Rocky Mountain National Park have much to offer biologists, particularly in relation to ecological and faunal studies.

# # #

SELECTION AND INDUCTION OF DROUGHT-RESISTANCE IN TREES FROM ECOTYPES IN THE COLORADO FRONT RANGE

INVESTIGATORS: G. H. Fechner)
C. P. P. Reid)
Michael Cline) Colorado State University
Laura Hall)

SUMMARY OF PROGRESS: Within the park boundaries, seed collections have been made from three locations on Fall River Road. Project-wide seed collections were hampered in the fall of 1974 by a late start, locally poor cone crops, and beetle infestation.

In addition to field collections of seed, activities during the first months have included refinement of techniques to determine drought resistance under a variety of water-stress conditions.

The project began in fall 1974, hence, no results are yet available.

PLANS FOR 1975: The 1975 field aspects of the project should continue as planned: collections of seed will be made along several altitudinal transects in Colorado, New Mexico, and Wyoming. Collections will be initiated earlier than in 1974, if funds are available.

During 1975, methodology to be used in testing drought resistance will be developed. Additionally, initial "screening" tests will be conducted in an effort to identify certain drought-resistant ecotypes.

# # #

RESEARCH ON ASPEN

INVESTIGATOR: Charles E. Olmsted
University of Colorado

SUMMARY OF PROGRESS: Efforts were concentrated on gaining a familiarity with the flora of the research area and making a survey of the Aspen stands in Hondius Park, Horseshoe Park, Beaver Meadows, and Moraine Park. There are no significant findings to date. Intensive research will be started in 1975. Sources of support at the University of Colorado and through granting agencies and institutions are being explored.

# # #

SMALL MAMMAL AND BIRD COLLECTION FROM ROAD KILLS

INVESTIGATOR: Jeffrey J. Hodge
Shiloa High School

SUMMARY OF PROGRESS: No mammals or birds were collected this last summer (1974). Nothing was found on the roads that could be used. I will try again next summer.

INSECT COLLECTION FOR PARK MUSEUM

INVESTIGATORS: Robert L. Pederson) National Park Service
Gretchen B. Pederson)

SUMMARY OF PROGRESS: We collected for 2 months at the end of last summer and hope to continue during the first 2 months of next summer. Specimens are being keyed to family. About 25% will be pinned and the rest preserved in alcohol.

# # #

UNGULATE HABITAT CONDITION AND TRENDS
ROMO-N-08a

INVESTIGATOR: David R. Stevens

OBJECTIVES: 1. Determine condition and trend of key habitats.

2. Determine departures from natural succession as affected by ungulate populations and relationships to the activities of man.

3. Formulate management objectives and criteria for ungulates.

METHODS: 1. Twenty-six browse transects were measured in April and May on the key winter range for form class, decadence, and percent leaders used on 25-40 tagged plants.

2. Vegetation in 17 agronomy cages were chipped and weighed for comparison with similar samples outside the cage to determine percent of available forage utilized.

3. Pellet groups for both elk and deer were sampled in 10 replicas of 100 ft^2 plots to determine relative use between species and years on each of the range transects.

4. Seven transects were observed and pellet group counts made on the alpine tundra of Trail Ridge.

RESULTS AND DISCUSSION: East Slope. According to pellet group counts deer use continues to decline in the Mill Creek-Hallowell Park area. This was also corroborated by ground observations. Bitterbrush (*Purshia tridentata*) did receive an increase in use from 30% to 37% but the condition of the plants still improved. Big Sagebrush (*Artemisia tridentata*) also improved in condition. Elk use increased over the last 2 years to 55 days/acre, although the forage utilization did not increase on the grass sites. Willow use, however, was up.

On the North Moraine, Big Thompson area, deer use also declined, although utilization on bitterbrush plants increased. This use increase probably was a result of elk since pellet group counts showed a 38% increase in elk use of this area. This was related to the decrease of elk use on both grassland and meadow sites. In the case of the large meadow area in Moraine Park the change was significant, declining from 83 days/acre in 1973 to 48 days/acre this year. Aspen and willow browsing also declined slightly.

On Deer Mountain the deer use also declined from 1973 but was similar to 1971 and 1972. Utilization of bitterbrush remained stable although elk use declined also on the south exposures. Utilization on sagebrush increased slightly, along with a related increase in deer use on these sites.

In the bottom meadows and grassland site of Beaver Meadows, elk use of the area remained stable. This was also indicated in the amount of grass use on the upland sites, but the grass use declined in the meadows. Aspen and willow use remained stable.

On the Fall River Moraine deer use, contrary to the other three areas, increased significantly. This was not followed by an increase in utilization on bitterbrush but thsee plants are used to the maximum already. Elk use declined to the lowest level in 6 years on the ponderosa pine south exposure. Elk use on the grassland and meadow sites remained stable, but grass use in the meadow increased to 71%, the highest measured to date. Both willow and aspen browsing increased slightly.

Looking at the overall East Slope deer range, animal use of the areas was down again in 1974. Although use on bitterbrush was up slightly, the condition of the range continues to improve for the most part.

On the elk range, although the elk population overall is increasing, the use of meadow sites decreased and grassland use remained stable. Actual percent utilization of grass also showed little change. This would indicate that changes in population densities are still being compensated for by better distribution on the range.

Alpine Tundra. Elk continue to winter on the alpine tundra. Seven transects and agronomy cages have been installed to measure changes in vegetation and attempt to relate it to elk use. Generally the use on the alpine is not measurable on the plots, especially on those with grasses, sedges, and forbs as the primary cover. The trend in use has been spotty and not consistent. Pellet group count on these sites since 1971 indicate a high of 12 days use per acre in 1973, decreasing to 7 this year on the four transects.

However, on the three willow marsh sites, considerably more use is made which is observable in the cages. The last 3 years the use of the sites as indicated by pellet groups has stabilized with 24 days use per acre recorded this year. Utilization on the willow is estimated at moderate to heavy.

Kawuneeche Valley. Each year a relatively small number of elk winter in the willow bottoms of the Kawuneeche Valley. Generally the number starts out fairly substantial but declines throughout the winter. Utilization on the willow plants is never much more than moderate, with 30% use in 1974. Movement away from the deep snow sites appears to be in two directions, back to the tundra of Mount Ida or Jackstraw Mountain or down the Colorado River to the vicinity of Willow Creek Reservoir.

PLANS FOR 1975: The utilization and condition trend of the range will continue to be monitored.

RECOMMENDATIONS: Based strictly on utilization and conditions of the key population determining range types, there is no indication that unnatural damage is occurring due to the high elk population. Willow and aspen sites continue to receive heavy use, resulting in varying degrees of change in plant densities.

# # #

A MANDATORY PERMIT SYSTEM AND INTERPRETATION FOR BACKCOUNTRY USER CONTROL IN ROCKY MOUNTAIN NATIONAL PARK: AN EVALUATIVE STUDY

INVESTIGATOR: James R. Fazio
Colorado State University

SUMMARY OF PROGRESS: A highly restrictive mandatory permit system coupled with rationing of use through campsite quotas was studied to determine visitor reaction to the system. A second part of the study consisted of experimental testing of selected interpretive techniques to determine which could be used to most effectively improve visitors' attitudes toward the permit system and increase visitors' knowledge of low-impact camping procedures.

The sample of 1020 backcountry users consisted of younger, wealthier, and more highly educated individuals than would be expected from a cross section of the American population. Most visitors were novice backpackers but their sensitivity to wilderness values was moderately high. A slight correlation was found between sensitivity to wilderness values and knowledge of low-impact camping, and between party size and sensitivity to wilderness. However, neither correlation was strong enough for predictive application.

The backcountry use permit system in Rocky Mountain National Park is probably the most restrictive in the United States. Nonetheless, it was found that generally visitors perceived the necessity of the program and their attitudes were supportive of its procedures.

Although most respondents viewed the system as convenient, waiting in line for more than one hour was common during the peak summer season. On some days close to 100 people were turned away. Advance reservations by phone or mail were not allowed (except for technical climbs not involving an overnight stay), but such provisions in other national parks were reported to be functioning satisfactorily.

A check of 912 backpackers in the backcountry revealed a compliance rate of approximately 92%. However, there were indications that because of unreported cancellations or parties not camping in the sites indicated on their permit, the number of camping parties in an area often did not coincide with the number recorded in the park's central control file. Law enforcement, although strongly supported by visitor opinion, appeared to be inadequate.

Visitors generally did not view metal fire rings and privies as necessary management facilities, but the majority did see the necessity of site markers. All facilities received higher support in a post-visit survey. Horse use of trails received the greatest number of unsolicited marginal comments, all of which were derogatory.

Visitor information and interpretation, particularly in response to pre-visit requests for backcountry information, were found to be inadequate in most of 17 national parks. sampled.

Of several interpretive techniques tested, none significantly improved the already high attitudes toward the permit system. However, knowledge of low-impact camping procedures was significantly increased using a slide exhibit synchronized with sound. Respondents exposed to brochures containing the same messages showed a mean increase not significantly different from the control group. The use of mass media (television and newspapers) was completely ineffective in that practically none of the backcountry users were reached by these methods.

# # #

SAGUARO NATIONAL MONUMENT

SURVEY OF DISEASES OF NATIVE ARID LAND PLANTS OTHER THAN THE SAGUARO
SAGU-N-17

INVESTIGATORS:	R. Gilbertson S. M. Alcorn M. R. Nelson	University of Arizona

SUMMARY OF PROGRESS: Twelve species of decay fungi have been found on saguaro. Of these only two are thought to invade living plants, *Poria carnegiea*, associated with a root rot, and *Phellinus texanus*, associated with a decay of wood in the trunk, especially near the arms. Three new species were found on saguaro and are being described in a paper submitted to *Mycotaxon*.

# # #

POPULATION DYNAMICS OF THE SAGUARO CACTUS
SAGU-N-26

INVESTIGATOR: Warren F. Steenbergh

OBJECTIVES:

1. Delineate and describe the existing saguaro populations of the monument in relation to the principal types of habitat and ecological situations in which they occur.
2. Detect and measure long-term trends of these populations.

METHODS: Periodic measurements on saguaros at Saguaro and Organ Pipe National monuments are used to establish size-age relationships and to compare growth rates.

A study involving photographic documentation and plot analysis of lightning damage to saguaro cacti was completed in 1970 (Steenbergh 1972).

A search for old photographs and historical records was undertaken. Saguaro study plots established at the east monument in 1941 were relocated for use in evaluating population trends. Photographs were taken to document the effects of freezing, grazing, fire, senescence, visitor impact, and other factors on saguaros and saguaro habitat.

A study to determine saguaro reproductive-vegetative growth rate relationships was initiated in 1969. Apical growth measurements of a sample of four saguaros approximately 4 m tall were made at regular intervals for one year. Two individuals used as controls were allowed to complete normal production of flowers and fruits. From the remaining two plants, flower buds were removed each week as they developed.

In 1971 a 2-ha (100 X 200-m) permanent sample plot was established in the lower bajada saguaro stand in the west monument. All saguaros are individually numbered, and the condition of each plant is recorded annually.

RESULTS AND DISCUSSION: Six 5-acre, 1941 saguaro study plots at the east monument were located and partially reestablished. Approximately one-half of the original 1941 photo points of Paul C. Lightle have been relocated, subjects rephotographed, and permanent photopoint markers installed.

Photographic evidence shows that substantial recovery from livestock grazing has occurred in both rocky and non-rocky habitats from which cattle have been excluded since 1958.

A report on the rejection of bacterial rot by adult saguaro cacti has been published in the *Journal of the Arizona Academy of Science* (Steenbergh 1970). A review of the literature on the so-called "bacterial necrosis disease" indicates that the susceptibility of saguaros to bacterial infection has not been tested by field experiments on naturally growing healthy adult plants.

The report on lightning-caused saguaro mortality was published in *The Southwestern Naturalist* (Steenbergh 1972). Lightning-caused destruction of saguaro cacti in the Tucson Mountains population is estimated at 0.51 to 3.18 plants per ha (0.6 to 4.0%); saguaro biomass converted, 520 kg to 2840 kg per ha (1.1 to 5.8%). Based on these values for lightning-caused mortality only, the biomass turnover period for this population is 17.2 to 93.1 years.

Apical growth-rate studies indicate that energy for reproductive growth is diverted from vegetative growth. Thus, (1) under a uniform environment, non-blooming individuals grow at a faster rate than blooming individuals of the same size and age, and (2) a change in the relationship between size and growth rate occurs when young plants reach blooming size.

In 1971, 6.35% of the saguaros (N = 189) in the 2-ha Tucson Mountain plot died from freezing. Complete results of 1971 studies are reported in a manuscript entitled *Ecology of the saguaro: I. The role of freezing weather in a warm-desert plant population* (Steenbergh and Lowe in press).

CONCLUSIONS: Healthy adult saguaros do not die from bacterial rot; natural response to injury confines bacterial rot to stressed or mutilated tissues immediately adjoining the site of the injury. Destruction by bacterial rot occurs in saguaros which are dead, senescent or otherwise lacking in normal vigor.

Lightning is an important cause of adult saguaro mortality. Physical evidence of lightning damage to saguaro cacti is distinctive. However, delayed examination can easily lead to the invalid assumption that death of the stricken saguaro is attributable to "bacterial necrosis disease" or other inappropriate causes.

The absence of reported lightning-caused mortality in the only published report on specific causes of adult saguaro mortality (Alcorn and May 1962) is attributed to failure to recognize lightning and other climatically caused saguaro deaths. As a result of the disease-like characteristics of subsequent natural decomposition, deaths of adult saguaros resulting from climatic factors other than wind--namely lightning and freezing--have been erroneously attributed to the so-called "bacterial necrosis disease."

Conclusions concerning the role of freezing weather in the regulation of saguaro populations at Saguaro National Monument are contained in Steenbergh and Lowe (in press, a). Continuing observations on freeze-damaged saguaros confirm that death of adult saguaros continues to occur for several years after the occurrence of a severe freeze.

The results of continuing analyses of saguaro growth rates, height and age relationships in different climatic environments, as well as other relevant results and conclusions developed during the course of this investigation are included in Steenbergh and Lowe (in press, b).

PLANS FOR 1975: Continue saguaro population and growth rate investigations. Continue rephotography and photo-documentation. Progress of this investigation has been seriously hampered by lack of funds for essential assistance. With the recent allocation of funds to provide for field assistance, it is anticipated that establishment and inventory of permanent population study plots and long deferred photo-documentation can be completed during 1975.

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# # #

CRITICAL FACTORS DURING THE FIRST YEARS OF LIFE OF THE SAGUARO CACTUS IN SAGUARO NATIONAL MONUMENT

SAGU-N-23a

INVESTIGATOR: Warren F. Steenbergh

OBJECTIVES: 1. To delineate and describe critical factors regulating germination and establishment of saguaro cactus in the principal habitats within Saguaro National Monument.

2. To determine the relative status and trend of saguaro seedling establishment in the principal monument habitats of this species.

METHODS: Field observations on wild seedlings, and field germination and survival experiments were initiated at the eastern (Rincon Mountain) section of the monument in 1965. Experimental studies were extended to the western (Tucson Mountain) section in 1967. Relative rates of seed attrition and germination success in various representative saguaro habitats were tested by broadcasting seed within preestablished plots and exclosures and observing the resulting germination under natural climatic conditions. After germination, periodic observation of seedlings was made to determine seedling growth, survival rates, and causes of mortality under these same conditions. Concurrent observations on relevant climatic, edaphic, and biotic factors were also made. Transplanted seedlings were also used to obtain additional data on seasonal mortality.

Observations on previously established seedlings were continued in 1969 together with small-scale seeding experiments to obtain further information on the effects of harvester ants, birds, and rodents. Limited trapping and field observation of rodents was done to obtain information on relevant habits of feeding and behavior. Periodic observations on transplanted pots of 4-month-old cultured saguaro seedlings were carried out to obtain information on climatically caused winter mortality.

Data on survival and freeze-caused mortality in natural and experimental populations of young saguaros in both east and west sections of the monument were obtained from 3 January to 21 November 1971. Observations were initiated concurrently with the onset of a period of sub-freezing nocturnal temperatures from 3 January to 10 January.

RESULTS AND DISCUSSION: A report on the first phase of this study appears in *Ecology* (Steenbergh and Lowe 1969). The final report on this project has been submitted (Steenbergh and Lowe in press, b).

Freezing weather was the primary cause of winter deaths in all populations of known-age seedlings and juvenile saguaros observed during 1971. Total 1971 freeze-caused mortality in experimental populations of 30-month-old saguaros (N = 568) was 52.5%. Lowest mortality was on south-facing slopes. Highest mortality occurred on north-facing slopes and in flat habitats.

Mortality of seedlings and juvenile saguaros less than 120 cm height was greatest in smaller (youngest) size-classes. Observable deforming injuries to stem tissues occurred in all height classes. Only plants less than 30 cm height, however, were completely destroyed by freezing.

Limited follow-up observation made during 1972 indicates that death as a result of freeze-caused injury can occur a year or more after initial injury.

A report on winter mortality entitled *Ecology of the saguaro: I. The role of freezing weather in a warm-desert plant population* (Steenbergh and Lowe) is awaiting publication by National Park Service.

A preliminary bibliography on the saguaro has been published for limited distribution by the National Park Service (Steenbergh 1974).

CONCLUSIONS: Conclusions are contained in the final report on this project entitled *Ecology of the saguaro. II. Reproduction, germination, establishment, growth and survival of the young plant* (Steenbergh and Lowe) which has been submitted for publication in the National Park Service Scientific Monograph Series. The report includes management recommendations, and a comprehensive bibliography of the literature on the saguaro co-authored by Warren F. Steenbergh and Lupe P. Hendrickson.

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# # #

TO DETERMINE IF THERE IS A RELATIONSHIP BETWEEN PRECIPITATION, TEMPERATURE, AND THE PERCENT OF YOUNG JAVELINA OBSERVED ON SURVEYS

SAGU-N-10a

INVESTIGATOR: G. I. Day
Arizona Department of Game and Fish

SUMMARY OF PROGRESS: The completion date will depend on the results obtained in 1974-75. This long-range study has shown a weak relationship between rainfall and javelina young survival. However, other variables such as temperature and forage production are now being examined to determine if they are related to survival of young javelina.

# # #

EFFECT OF RODENT EXCLUSION ON VEGETATION AT SAGUARO NATIONAL MONUMENT
SAGU-N-5a

INVESTIGATORS: Ray M. Turner, U. S. Geological Survey
Stanley A. Alcorn, University of Arizona

SUMMARY OF PROGRESS: The six plots established in conjunction with this study have been remapped this year. Results are not summarized as yet.

# # #

AN ORDINATION AND QUANTITATIVE ANALYSIS OF THE PERENNIAL VEGETATION
SAGU-N-37

INVESTIGATOR: William H. Brooks
Pima College, Tucson

SUMMARY OF PROGRESS: Because of fuel shortages imposed during last winter and early spring months, not as many additional stands were surveyed as anticipated (Year-end Report, 27 December 1973). Data from several previously surveyed stands were combined as indexes of similarity and topographic features showed no significant differences between them. An additional five stands were surveyed in the higher elevations of the Tucson Mountain unit bringing the total stands established for this study to twenty. Included in the total are major topographic aspects represented in the lower and higher elevations of the monument. With the completion of data collection, stands have been placed into an ordination, and behavior indexes have been calculated (relative cover X frequency) for the dominant species to further indicate their patterns of distribution with respect to the several physical environments represented in the study.

The investigator is currently in Saudi Arabia and has been out of the area since last spring. During the next several months, however, a final report will be prepared and forwarded through the proper channels with the hope that publication of results from this study can be anticipated.

My thanks and appreciation are gratefully extended to the staff at Saguaro National Monument (East and West Units) for the encouragement so freely rendered during the course of this study.

# # #

PHENOLOGICAL STUDIES OF DESERT PERENNIALS
SAGU-N-49

INVESTIGATOR: Tien Wei Yang

SUMMARY OF PROGRESS: Summaries of significant findings are in the form of unpublished reports for International Biological Program. Work is progressing in both units of the monument.

# # #

ANALYSIS OF EFFECTS OF VEGETATION PARAMETERS ON BIRD SPECIES DIVISIONS

SAGU-N-40

INVESTIGATOR: Eric Yensen
University of Arizona

SUMMARY OF PROGRESS: Work has been completed. A copy of my dissertation based on this work was turned over to Warren S. Steenbergh upon completion. Significant findings include a lack of precise correlation between major taxonomic groups along the diversity gradient and a testing of vegetation predictors of bird species diversity. Much additional information on community composition and structure is included.

# # #

HEIGHT AGE RELATIONSHIPS IN THE SAGUARO CACTUS

SAGU-N-28

INVESTIGATOR: Stanley M. Alcorn
University of Arizona

SUMMARY OF PROGRESS: This has been an open-ended project involving annual measurements of saguaros of various heights to better establish growth-age relationships.

I will not be able to continue there in 1976 and possibly not in 1975. However, it is expected that Raymond Turner will continue the measurements (but perhaps on a less frequent basis).

# # #

INVESTIGATION OF FACTORS REGULATING BIRD POPULATIONS AND DISTRIBUTION

SAGU-N-24

INVESTIGATOR: Stephen M. Russell
University of Arizona

SUMMARY OF PROGRESS: I was unable to work on this research in 1974 due to other commitments. I do wish to keep one project viable--field work anticipated in the future will provide useful comparisons with that already done.

In 1974, my ornithology class used the marked plot in Saguaro West on two days. I am keeping one plot survey line in good shape. I expect to use the plot in spring 1975 with one ornithology class.

# # #

TAXONOMIC STUDIES OF THE BACTERIAL SPECIES OF *ERWINIA CARNEGIEANA* IN COMPARISON WITH OTHER SOFT ROTTING ERWINEAS

SAGU-N-9a, 15, 20a, 29

INVESTIGATOR: S. M. Alcorn
University of Arizona

SUMMARY OF PROGRESS: Should finish this year morphological and physiological tests relating to the above subject. We probably will suggest that *Erwinia carnegieana* should be renamed.

# # #

VIRUS DISEASES OF CACTI AND OTHER NATIVE PLANTS

SAGU-N-19a

INVESTIGATORS: M. R. Nelson) University of Arizona
Raymond Wheeler)

SUMMARY OF PROGRESS: Michael A. Yoshimura is in the final stages of completing a Ph.D. dissertation on the *Origin and physiochemical stability of the saguaro virus*. His findings will be published in two papers, one in *Virology* or *Journal of General Virology* and the other in *Phytopathology*. The former will involve his work on reversible and non-reversible changes in structure and physical properties mediated by alterations (salt, pH, enzymatic) in the fluid laboratory environment and analyzed by electrophoresis, ultracentrifugation, electron microscopy, serology, and bioassay. The latter paper will deal with the results of his search for a source of the saguaro virus. In the process he has found a number of new plant genera in several famillied of the caryophyllales susceptible to the saguaro virus and one virus from nursery-acquired carnations that resembles (but is not identical to) the saguaro virus. He has experimentally infected saguaro seedlings with the virus from carnation. Thus a link has been found with a cultivated plant which supports our theory stated in last year's report that this virus is a biological contaminent of the desert biome. Yet to be determined, does the saguaro virus infect carnation? Does the carnation virus exist in native saguaro?

We have been invited by the Commonwealth Mycological Institute (England) to write a description of the saguaro virus for their internationally authoritative series *Descriptions of Plant Viruses*.

# # #

TRENDS IN SAGUARO ESTABLISHMENT SINCE THE 18TH CENTURY

SAGU-N-13a

INVESTIGATOR: Ray M. Turner
U. S. Geological Survey

SUMMARY OF PROGRESS: The saguaro study plots established in conjunction with this project were each measured for the third time this year. Data from these and the eight other plots of this study are currently being analyzed.

ST. CROIX NATIONAL SCENIC RIVERWAY

RESOURCE INVENTORY OF THE ST. CROIX AND NAMEKAGON RIVERS

INVESTIGATORS: Peter J. Olin) University of Minnesota
Margaret Smithberg)

SUMMARY OF PROGRESS: Progress to date has been a review of all studies done on the St. Croix and Namekagon rivers to determine what resource information is available and its form, relevancy, and accuracy. One man-month of time has been spent to date.

There are apparently two basic data gaps, both within the state of Wisconsin, involving soils and vegetation data. The study planned for the next two summers will try to fill in these missing gaps and map the information at a scale of 1 inch = 2000 ft. All existing resource data will be gathered and analyzed in comparable terms relating it to its compatibility to planned recreational development. All maps will be at a scale of 1 inch = 1 mile or 1 inch = 4 miles. An outline of the next two summers' work will be forwarded by the end of January 1975.

# # #

SAN JUAN ISLAND NATIONAL HISTORICAL PARK

ZOOPLANKTON POPULATIONS IN JAKLE'S LAGOON

INVESTIGATOR: Karl Banse
University of Washington

SUMMARY OF PROGRESS: Jakle's Lagoon is a small, periodically isolated body of water in the high intertidal of San Juan Island. It offers an opportunity which is very rare in the marine environment, to revisit the same individuals of zooplankton populations and to apply the tools of population dynamics to them. Because of the partial isolation from the sea (interrupted only at spring tides), the water is the warmest environment in the San Juan Island that is easily accessible for any of the marine stations of Washington. The high summer temperatures are the cause for some unusual occurrences of specimens useful or important for the teaching and research at the laboratories but also lead to rapid developmental times of the organism studied by the zooplankton workers. Therefore, given the finite time limit of summer quarter as far as the students are concerned, work can be performed that cannot be done anywhere else in the region. Moreover, the lagoon does not receive appreciable fresh-water runoff and is unpolluted; because of the slight inconvenience of access, few people reach it so that floats, markers, or cages (not used this year) are left undisturbed.

The oceanography classes offered at the laboratories use the lagoon as a teaching as well as a research tool for 10-12 graduate students and faculty. There are class projects centered around regular collection of plankton and environmental data, and research projects (often combined with laboratory studies on specimens from the lagoon).

Investigations on rate of egg-laying, development, food uptake, and similar problems by the dominant planktonic copepod crustacean *Acartia* were done in the laboratory. These can be regarded as training exercises without results worth reporting, although they were important as such.

# # #

ESTUARINE STUDIES AND POPULATION DYNAMICS OF CLAMS

INVESTIGATOR: Vincent F. Gallucci
University of Washington

SUMMARY OF PROGRESS: The research is progressing satisfactorily. We now have a good estimate of the standing crop and the age distributions of the species. Our estimates of the number of clams leaving the park are not very good but we will try to improve on that this year with the cooperation of the superintendent. We had some difficulty determining recruitment to the populations. This will also be emphasized this next year. We have written the first of several planned public interest brochures designed to inform visitors of how to dig effectively and with minimal ecological damage. We will be doing more on the public education aspect these coming years.

In summary, we are interested in knowing how many clams are present (their species and age distribution), how many are added each year, and how many are currently taken from the beach by park visitors. We have completed the first phase and started the second and third which we must now concentrate on. In the last year we will return to the first phase to estimate the effect of the regulations we have imposed.

At this point I can make no recommendations about changes.

# # #

POPULATION DYNAMICS AND PRODUCTION OF THE MARINE COPEPOD *ACARTIA CLAUSI* IN JAKLE'S LAGOON

INVESTIGATOR: Michael R. Landry
University of Washington

SUMMARY OF PROGRESS: The population of *Acartia clausi* in Jakle's Lagoon has been sampled for a period of 1.5 years (February 1973 to September 1974) at intervals of 3-4 days in the summers and bi-weekly in the winters. Environmental variables (temperature, salinity, and chlorophyll) were also sampled at these times, and periodically fish were taken for gut analyses. Controlled environment experiments at Friday Harbor Laboratories were coordinated with the program in the field in order to determine the controlling factors of the population fluctuations (dynamics). Counts of all field samples have recently been completed, but at this time the data has not been analyzed in full.

This area should be preserved for its unique scientific properties. It provides one of few natural "laboratories" where an isolated population of marine planktonic animals can be studied and the factors which key population fluctuations precisely determined.

# # #

INVESTIGATIONS ON THE NANOPLANKTON IN JAKLE'S LAGOON AND TWO SMALL LAGOONS OCCURRING AT THE SITE OF OLD TOWN

INVESTIGATORS: Richard E. Norris) University of Washington
Richard Pienaar)

SUMMARY OF PROGRESS: The enclosed nature of the lagoons used in this study allow species of nanoplanktonic organisms to become concentrated, often in very high numbers. Such concentrations of these organisms make their investigation possible, contrary to the few specimens that may be found in outside natural waters. The nanoplankton organisms that we are studying are often very small, from 1 to 25 microns in length, and are often flagellate. We are now growing many isolates from these lagoons in the laboratory and have been able to study some of them under very high magnifications with the electron microscope. A very high percentage of the total primary production of these lagoons, as well as the sea in general, is due to nanoplankton organisms. Our studies, as a result, are dealing with a highly important part of the biological population. We have found that there are numerous species of nanoplankton in these lagoons that are probably undescribed and, therefore, previously unknown to science. Practically all of the organisms that we are studying have not been previously recorded from this region and most of them are unknown to North America before this time. We plan to continue our studies on the ultrastructure, taxonomy, and reproductive life histories of these phytoplankton organisms. Much material has been fixed and embedded for sectioning and study under the electron microscope, and we have at this time studied only a small number of the species in our collections at these very productive lagoons. Publications are planned on this material, and at this time we can estimate that approximately 12 papers will be written in the next 3 years.

# # #

THE BIOLOGY OF THE RABBIT *ORCYTOLAGUS CUNICULUS* IN SAN JUAN ISLAND NATIONAL HISTORICAL PARK AND VICINITY

SAJU-N-1

INVESTIGATORS: A. R. Weisbrod, USNPS Cooperative Park Studies Unit
W. Frederick Stevens, University of Washington

SUMMARY OF PROGRESS: Field research on this project was terminated after 8 consecutive months of study in the park and vicinity. Investigations into the biology of the rabbit *Orcytolagus cuniculus* during this time period were directed toward both refinement techniques and confirmation of data collected in previous field seasons (1972-73). Detailed mapping of a 48-ha study area locating rabbit warren in relation to vegetation and microenvironmental features were completed. Studies of phenology and plant productivity in relation to rabbit breeding cycles were concluded. Monthly 3-4-day field trips are being made to the park to continue population census and observation of dispersal activity.

The final project report in the form of a thesis was begun in September 1974 and should be completed by June 1975. A copy of the thesis will be provided to the park and regional headquarters.

Publication

1974. The skylark in Washington. *Auk* 91:832-835.

# # #

SEQUOIA AND KINGS CANYON NATIONAL PARKS

LILBURN CAVE AND THE KARST OF REDWOOD CANYON
SKC-N-33

INVESTIGATOR: Stanley Ulfeldt

SUMMARY OF PROGRESS: Survey and Exploration. Most of the effort this season was on completing the survey of the known portions of the cave and the surface areas over the cave. Preparation of accurate maps of the cave and the surrounding surface area is well along. Hydrology and Geology. Efforts to find evidence related to the chronology of the development of the cave have begun. Information on the sediments in the cave has been collected and arrangements made to run paleomagnetic and pollen analysis on them. Biology. A cave adapted Isopod was found in Lilburn cave this fall. Thomas E. Bowman, Curator of Crustacea at the Smithsonian Institution, identified it as "an undescribed species belonging to the genus *Asellus*." This is the second known occurrence of a cave adapted Isopod in California.

PLANS FOR 1975: The thrust of the project will shift toward the identification of areas for potential research and the initiation and/or support of specific research projects in these areas. In the following year a biological survey will be undertaken and paleomagnetic measurements will be made on the sediments and fills in the cave.

# # #

THE INFLUENCE OF FIRE ON THE NUTRIENT STATUS OF GIANT SEQUOIA FOREST SOILS
SKC-N-35

INVESTIGATORS: Philip W. Rundel) University of California, Irvine
Theodore V. St.John)

SUMMARY OF PROGRESS: The work up to 31 October 1974, consists of a burn experiment in which soil fertility changes were followed seasonally, and a fertilization experiment in which the ability of two conifer species to absorb sudden releases of nutrients is being assessed. Work still planned includes laboratory tests to determine the relative amounts of nutrients released after burning of litter of several species and to investigate changes in solubility of soil nutrients after heating. Greenhouse tests of response to large nutrient availability are also planned.

Burn Plot Experiment. A control and a burn plot were established on Redwood Mountain in an area that had not been included in recent prescribed burns. A 30 X 30-m plot was burned by National Park Service personnel in October 1973. Soil samples were collected during the fall, winter, and spring so seasonal changes in solubility of these elements could be assessed. There were five collection dates between October 1973 and June 1974. On each occasion composite samples were taken from 18 subjects on the burn area and 12 subplots on the control area. After determining that this subplot system afforded no reliable basis for determining the effects of local fuel abundance, most of the samples were combined into a single burn and a single control sample for each collection date. The samples were kept frozen until analysis to prevent microbial activity. Analyses have been completed for soluble phosphorus and partially completed for total phosphorus and total nitrogen. Soluble nitrogen analyses still remain.

The soluble phosphorus data show a trend toward maximum availability in the spring soon after the snow melts. On each sampling date, the burn plot had a higher level of available phosphorus than the control plot. A follow-up study this winter will compare foliar nutrient levels of plants on burned and unburned sites to see if uptake corresponds to the pattern of changes in the soil.

Fertilization. A fertilization experiment is being conducted at Whitaker's Forest to assess the relative ability of white fir and ponderosa pine to use a sudden flush of nutrients as occurs after a fire. Samples of foliage are being taken for analysis from comparable-size trees on untreated, fertilized, and cleared plots. With white fir there are untreated trees on both sunny and shady sites. The additional treatments are used to detect an effect of these on foliar content that may not be due to added fertilizer. It is hoped that any response to fertilization will be visible in trees on burned sites, and may be used as an index of the benefits derived from the fires.

Lab Burning. Samples of freshly fallen leaves are to be analyzed for nutrient content, and the ash of the same leaves will be anlayzed. This will illuminate the contribution of litter of each species to the fire-induced nutrient flux. The effects of heat on sequoia forest soil will also be tested in the laboratory.

Greenhouse. The response of individual sierran conifer species to take "flush of nutrients" effect will be investigated in some detail with greenhouse-grown seedlings. It is hypothesized that fire adapted species are able to store relatively larger amounts of nutrients than non-fire species, and thus may be genetically adapted to fire as a source for available nutrients.

# # #

STUDIES OF THE MONOTROPOIDEAE (ERICACEAE)

INVESTIGATOR: Gary Wallace
Rancho Santa Ana Botanic Garden

SUMMARY OF PROGRESS: I completed my Ph.D. dissertation in July 1974. I have gathered almost all of the material I need for anatomical and morphological study. I am preparing papers on these aspects as well as others on the ecology and pollination biology of the group. I need to gather more information from the field on the pollination biology and dispersal of these organisms. Seasonal development will also be investigated as well as gathering of material to count chromosomes of the taxa.

# # #

EFFECTS OF FIRE AND SODIUM-CALCIUM BORATE ON CHAPARRAL VEGETATION
SKC-N-7

INVESTIGATOR: S. K. Stocking
San Joaquin Delta College

SUMMARY OF PROGRESS: (1) Some comparison photos have been taken during two study trips to the plots. More to be taken in the spring of 1975. (2) Soil samples have been collected from the area burned in 1960 and an attempt is being made to determine if viable seeds of fire-type species are present. (3) The woody vegetation of the burned and control plots has been surveyed and comparisons are being made with the woody vegetation which appeared following the fire.

FINDINGS TO DATE: (1) There has been little change of the woody perennial vegetation on the unburned control plots. (2) Some short-lived perennial species are dropping out of the vegetation of the area burned in 1960. (3) These same two short-lived species are now abundant on the area reburned in 1970 (subclimax species). (4) The margin of the grassland and chaparral, and woodland and chaparral has not changed in this area since 1960. There is no evidence of "invasion" of one community by another.

# # #

ECOLOGY OF GIANT SEQUOIAS

SKC-N-1

INVESTIGATORS:
Richard J. Hartesveldt)
H. Thomas Harvey)
Howard Shellhammer) San Jose State University
Ronald E. Stecker)

SUMMARY OF PROGRESS: Our 10 year field work was completed during the summer of 1974 with the exception of possible field checks to aid in the preparation of the final monograph. A rough outline of the monograph has been prepared and is being expanded at this time, following suggestions from biologists in Sequoia/Kings Canyon National Parks and the Regional Office. Due date: February 1976.

Activities during the summer of 1974 consisted of:

1. Sequoia Insect Studies, R. E. Stecker

A study of some of the basic ecological relationships of insects and *Sequoiadendron giganteum* has been conducted in Redwood canyon since 1966. The investigation has emphasized two phases: insect related loss to seedling sequoias, and in-crown research on insects causing release of seed from ovulate cones of mature trees.

Seedling plots and transects reveal losses to seedlings between 3.4% to 17.5%. Insects responsible for this loss were larvae of *Sabulodes caberata* and *Pero behrensarius* (Geometridae), and early instars of a camel cricket *Pristocauthophilus pacificus* (Gryllacrididae). A parallel was observed between extent of insect loss and lapsed time since severe ground disturbance, such as fire or scarification. New growth in fresh burn areas had maximum hypocotyl loss of 17.4% and defoliation of 34.2%, while control and non-burn plots ranged between 4.2% to zero loss (attributed to sequoia seedlings being the only source of food available after burning, before more desirable food sources became established).

A 290-ft giant sequoia rigged with an electric elevator and climbing lines has been studied since 1968. Two insects studied have been found to cause release of seed following mining activity which disrupts the vascular flow and causes cone scales to dry, open, and release seed. This tree species does not release its seeds without the intervention of outside forces. Living cones may remain on the tree for 22 years or more. *Phymatodes nitidus* (Cerambycidae) mines the axial shaft of these cones in the larval stage playing a major role in seed-release. Over 84% of the attacks occur in cone age classes of 4-9 years. Gelechiid larvae (*Gelechia* sp.) attack the fleshy first year cones. Studies show incidence of attacks increased with number of new cones each year. Only 51% of the individuals attain adult stage with most larvae pitched-out in the first and second instars at their point of entry at cone scale junctures. Incidence of this insect is also distinctly clumped in the upper crown of the tree.

A "reproductive strategy" can be constructed for the giant sequoia using one physical and three biological agents, where *Gelechia* exclusively uses the first year cones, *Tamiasciurus douglasii* (a squirrel) cuts cones 2-5 years of age, and *Phymatodes nitidus* releases seed from cone classes of 4 years and older. This continuum avoids competition and provides seed release over a long period within a year, and between years, for these long-lasting ovulate cones. The peak seed viability of the 5-year cone class is situated at the meeting point of *Tamiasciurus* and *Phymatodes* activity. When ground conditions become too littered and shaded, thus being unsuitable for seed germination, fire may play the role of backup agent by killing cones with superheated air, causing the release of seed.

2. Sequoia Ecology Studies (a) Sequoia Regeneration, T. Harvey and R. Hartesveldt

The following represents preliminary conclusions from the vegetation and vertebrate coaction portions of this final field season of what has been a 10-year project.

During the summer thus far the long-term study has yielded mainly expected results. The surviving seedlings presently constitute about 5% of the over 7000 original individuals. The best growth, of about 25 cm/year, has occurred in seedlings in old burn piles where relatively high soil moisture is prevalent. Many suppressed seedlings, less than 10 cm tall, still cling to life in relatively dry and/or shaded sites. Based on the populations extant in the Redwood Mountain Grove and Giant Forest Grove a mortality of the order of 99.99% of the seedlings in the study areas could be sustained over the next 500 years and still yield enough replacements for that section of the grove. In an effort to remove some of the uncertainty in the reproductive capacity of the giant sequoia, seed counts were made on about 200 cones. These data indicate that seed number per cone varies with respect to tree, number of cones scales and possibly to cone size. From the cones examined an average of about 200 (202.4) seeds per cone was obtained and about 34 (33.5) scales per cone. These data linked with the cones per tree and trees per acre will aid in determining the seeds dropped per acre and thus this vital stage in the reproduction of the giant sequoia. Correlation coefficients will be calculated for the above combinations.

Evidence was gathered via increment borings to further substantiate our contention that along the perimeters of some groves there are places of grove expansion. Redwood Mountain Grove, Lost Grove, and Grant Grove seem to exhibit this phenomenon but ring counts from the cores and basal area regression curves will have to be plotted before this is confirmed.

Ground vegetation was examined on all permanent plots. The data have not been compared with previous years as yet but appear to follow the trends as expected in succession. Specifically, the annuals which came in after the fire are now fewer in number while the shrubs that came in have maintained their numbers. Some perennial herbs, such as lupine, have clearly increased in numbers and in fact one study area is nearly carpeted with lupines. This adds an aesthetic quality to the area particularly when the lupines are in full bloom. Only by plotting all the data on ground vegetation will the magnitude of the changes be clearly evident.

The tree strate were assessed by remeasurement of the large 5 X 20-m plots and the random pairs' sampling lines. These data have not been fully analyzed but it is evident that the density of the larger trees (over 3 m in height) has decreased in the manipulated areas. A specific survey of snags larger than 6 inches dbh was made through all study areas. The data obtained indicate about 5 snags per acre in the manipulated portions to about two and one half snags per acre in the control portions. This increase in standing or fallen dead wood in burn areas leads us to the following recommendations:

We recommend that dead snags resulting from the first prescribed burns be felled and burned in a second prescribed burn. We further suggest that the process be monitored at least as to increased damage to sequoias, additional killing of white firs, and effect on sequoia reproduction. Evaluation of these parameters should aid in deciding whether a third and possibly a fourth prescribed burn is desirable in a given area.

We further recommend that only portions of sequoia groves be prescribed burned, not the entire grove. Those areas with no sequoia regeneration and/or high fuel levels should be given high priority. Some areas should not be burned, i.e., areas with low fuel levels and high sequoia regeneration. Our studies and those of Rundel and Bonnickson indicate that these groves are a mosaic of plant assemblages and to treat them all the same is questionable.

(b) Vertebrate Coaction Studies (douglas squirrels), H. Shellhammer

(1) Douglas squirrels (chickarees) have varied greatly in numbers in and near our study

area. There were an average of 5/ha (2/acre) in 1966 (one area was as high as 10/ha or 4/acre) while there are less than 1/ha (1/25 acre) in 1974. Their density hence varied by 100 fold in the 10 years of our study. Territory size was as small as 0.275 ha (0.5 acre) in 1966 while the area of use (most of which was lightly defended) in 1974 has grown to more than 10 ha (25 acres).

(2) Most of the cones eaten off sequoia trees were cut and eaten in the trees rather than at "kitchen middens."

(3) Most of the large (6 ft + dbh) sequoia trees in our study areas were cut at least once in 10 years. Eighty-five percent of the 65 trees were cut at least once. Fifty-five percent were cut from 1 to 3 years and about three percent were cut in 9 of the 10 years. The average number of cones (208) cut per tree per year was small as many trees were cut lightly, especially in years of low chickaree density. Some trees, however, were heavily cut losing 12,500, 11,000, 10,500, or 10,050 cones respectively and usually lost such cones in 4 or 5 years. Heavy cutting on trees with low cone loads produced a major impact on the cone load of such trees.

(4) Chickarees do not seem to pick out sequoia trees in which to live on the basis of the cone loads of the tree but are often "forced" to occupy them because of the territorial spacing mechanisms of this species.

(5) The number of cones cut is greater in years when there are large numbers of chickarees. Cone cutting, in part, is a manifestation of territoriality. Chickarees in years of high numbers stay in one sequoia, cut heavily, cache cones in great numbers and cut cone throughout most of the year. The converse is true of chickarees in low years.

# # #

DECOMPOSITION RATES OF MEADOW HERBAGE IN THE CENTRAL SIERRA NEVADA

SKC-N-17b

INVESTIGATOR:	Raymond D. Ratliff Pacific Southwest Forest and Range Experiment Station
SUMMARY OF PROGRESS:	Samples put out in September 1973 were recovered and a third set was put out. The recovered samples have been processed but the results have not yet been analyzed.

Results from the first set of samples (1972-73) have given the following results: (1) Native herbage--buried or unburied samples have given the same results on all five meadow sites. That is on a given site there was no difference in percentage of weight lost. (2) Buried filter papers lost more weight on four of the five sites than did unburied filter papers. (3) Buried filter papers lost more weight on three sites, less on one, and the same weight on one site than the herbage samples. (4) For all sites combined the percentage of weight lost was 64.9, 34.3, 60.8, and 57.4 for buried and unburied filter papers and buried and unburied herbage, respectively.

# # #

RAE LAKES
SKC-N-40

INVESTIGATOR: Don Erman
University of California, Berkeley

SUMMARY OF PROGRESS: Initial progress has been a reconnaissance of Rae and Sixty Lakes basins in July 1974, and analysis of water samples from a number of the lakes. We have begun assembling and testing equipment and methods for use in the remote areas.

Significant findings so far are limtied to our analysis of water samples. Concentrations of NO_3 and PO_4 are very low and will require special spectrophotometric equipment for on-site analysis. We suspect that because of the very low concentrations and long storage times, our initial samples from the lakes are unreliable. On-site determinations and use of a 10-cm light path should overcome these problems.

Recommendations for future work are to proceed basically as planned. We will need to keep some special equipment (line-powered spectrophotometer) in a car in Onion Valley for periodic checks of field methods. We will also take in resin columns for making deionized water in the field.

# # #

SPOTTED OWL SURVEY

INVESTIGATOR: Gordon I. Gould, Jr.

SUMMARY OF PROGRESS: Surveys to locate spotted owls were conducted throughout the wooded, montane areas of California from 18 July to 28 September 1973 and 4 March to 12 July 1974. Owls were located using recorded and vocal calls, calling either continuously or at intervals along roads and trails through logged and unlogged areas.

Literature and museum records established the past distribution of spotted owls in California. Present distribution was determined in 33 counties extending along the north coast from Del Norte County to Marin County, along the south coast from Monterey County to San Diego County, and along the western slope of the Sierra Nevada Mountains from Kern County to Plumas County. A minimum of 263 spotted owls, representing 192 pairs, were located. Five major population concentrations were noted. The lowest relative abundance of spotted owls occurred in the northern part of the south coast area and the highest in the Douglas fir belt in the north coast area and in the mixed conifer belt of the southern Sierra Nevada. The spacing of adjoining territories and minimum territory size were estimated. A reduction of 27% in the number of occupied, historical sites may indicate a downward trend in the population size of spotted owls in California.

Spotted owls were located most frequently in dense conifer forests. Dominant tree species at each site were noted and varied from one geographic area to the next. Tree sizes, decadence and density were noted at each site as well as elevation, topographic situation, slope exposure, and water availability.

Spotted owls were found in park or suburban areas where human activity was great at 14% of the sites. Logging was known to have occurred at or near 71 sites. Owls occurred in some logged areas and in areas of human activity where there was still extensive and dense forest. Where logging was more extensive spotted owls may have been exterpated. In other areas logging may reduce the number of pairs of spotted owls in an area; the degree of reduction may depend on timber type.

RECOMMENDATIONS: As a result of this study, and based on information available at this time, the following recommendations are made to ensure the maintenance and preservation of the spotted owl in California: (1) A breeding study be conducted to determine if spotted owls located in or near logged areas are breeding at a rate similar to owls located in areas not affected by logging or other disturbances. (2) A study of the exact territorial requirements be conducted if spotted owls can't maintain stable population numbers in areas where logging is occurring and if individual pairs are to be maintained on commercial timberlands where continuing harvest will occur. (3) Existence of known pairs be monitored every 4 years to observe population trends. (4) Areas which fit the habitat requirements be checked for the presence of spotted owls. (5) Consideration be given to the habitat requirements of spotted owls in forest and timber management plans.

# # #

BLACK OAK FIRE ECOLOGY

SKC-N-37

INVESTIGATOR: James Sellers
Kingsburg High School

SUMMARY OF PROGRESS: Black oak seedlings have increased significantly although the increase is not directly related to the controlled burn. These seedlings are more widely distributed than at the beginning of the study indicating some source of seeds from outside of at least one plot. The seeds are probably carried by squirrels, deer, and birds.

Black oak saplings have shown susceptibility to fire even in those areas where the fire was light. These saplings have shown the ability to stump sprout.

Black oak trees in the small age-class are susceptible to fire which seems to indicate that the sapling-early tree period in the life of a black oak is not resistant to even a light fire. Established mature trees in the large age-classes have showed considerable resistance to fire.

The seedling counts of black oak indicate good reproduction with the sapling-early tree stage being the critical time period in the life of black oaks. Causes other than fire may be at work in the limiting of black oak populations. It should be noted however, that the sapling-early tree stage of black oak is not only missing in our study plots but in the Cedar Grove canyon as a whole.

# # #

CARPENTER ANTS AND GIANT SEQUOIAS

INVESTIGATORS: David Wood)
Charles David) University of California, Berkeley

SUMMARY OF PROGRESS: Entomology. The numbers of carpenter ants in areas of high and low human use have been estimated for a third season, this time in more than 100, 10 X 50-m transects. Contrary to the last report there is a correlation between the number of *Camponotus modoc* and the number of fir trees over 10-cm dbh found in each transect. Areas with the highest ant populations are those with the most firs. This result is consistent with past observations that the major food source of these ants is honeydew from aphids in the genus *Cinara* feeding on these trees. In transects containing the largest number of firs, a higher percentage of these firs are found with ants climbing them than in transects with fewer firs. This indicates that if the numbers of fir trees in an area were to be reduced, or made unavialable to the ants, the numbers of ants might decrease disproportionately. A less significant correlation exists between the numbers of ants and an estimate of human use in a particular area. This correlation is absent if the areas around Round Meadow and Hazelwood are excluded from the analysis. There must be come other explanation for the high ant populations in these areas. A correlation exists between the numbers of *C. modoc* in a transect, and the numbers of *C. vicinus* in that transect. Where there are more *C. modoc* there are less *C. vicinus* which indicates there may be some competition between these two species. There appears to be a superabundance of nest sites available to these ants which indicates that nest sites are not limiting population size.

The number of aphid colonies on white fir in the Round Meadow area is much larger than in the Circle Meadow area where there are far fewer carpenter ants. In other areas with many carpenter ants the numbers of aphid colonies is similarly high. In exclusion experiments, where ants have been denied access to aphid colonies by bands of sticky material, colonies disappear more rapidly than colonies with ants in attendance. After 32 days, the aphid colonies had disappeared on both of the trees where ants were excluded, while 6 out of 10 colonies on the check tree were present. Ants apparently protect the aphids from predators. But behavioral changes in unattended aphids, such as a higher tendency to disperse and/or the increased production of alate forms, may also be involved.

Foraging behavior of *C. modoc* has been studied in detail. As the season progressed a greater number of aphids were carried back to the nest. Some trails contained many ants carrying aphids and only a few possessed honeydew while on other trails the reverse situation was observed. There was a higher percentage of ants with honeydew at the base of fir trees than at the nest entrance. None of the ants leaving the nest possessed honeydew in their crops. Only 12% of the ants returning down the fir trees were carrying food other than honeydew or aphids. Of 116 objects observed being carried down fir trees that were not aphids, one-half were aphid predators. Foraging by the ants is mainly confined to trails. Although these are marked by a scent, ants walk in straight lines orienting primarily by vision to landmarks. The ants can thus cross over disturbed portions of the trail. An ant can recruit other ants to a food source some distance from a trail. The ant walks back to the nest orienting by vision. We have not been able to demonstrate that any scent is laid down at this time. On reaching the nest the ant enters, and almost immediately leaves again laying a trail with the tip of the abdomen to the food source. A file of ants follow the leader back to the food source. The lead ant at this time is orienting by vision. If it is removed from the trail the ants following become disoriented and eventually return to the nest. *C. modoc* follows a pentane extract of the hind gut alone, just as they follow the lead ant. They do not appear to follow formic acid trails.

None of the queen ants observed burrowing into logs in June 1973 could be found during the 1974 season. In May 1974 queen ants were observed entering ant nests following a marriage flight. This behavior has been observed in European ants related to *C. modoc* but not in any North American species.

The activity and populations of ants in the plots studied in the previous two seasons have been reinvestigated.

The abundance of ants in the burned and unburned areas at Redwood Mountain has been reevaluated. Ant nests in Sequoia trees and stumps are still present, while those in fir stumps and logs have disappeared two seasons after the burn. The population of an ant nest at Round Meadow has been studied for three seasons. Estimates of the foraging populations were obtained this year by measuring the flow of the ants along the trails, and by removing samples of ants from the trails. This nest had a foraging population in August of about 4500 ants. Over a period of several weeks 1750 ants were removed from one trail. After each removal the estimated numbers of ants on the trail derived from flow rate measurements fell by the same amount as the number of ants removed, and then slowly increased night by night. The number of ants on the two other trails from this nest increased slowly through the experiment as did the number of trails from neighboring nests. About 1200 ants were added to the foraging population of this nest. About 1000 were added to the population on a trail from a neighboring nest between 31 July and 1 September. About 2700 ants were present in July. The general distribution of ant trails and nests in the plots has remained constant in 1972, 1973, and 1974, and the estimated size of the foraging populations from these nests has not changed in this period. The ants added to the foraging populations in August seem to replace those lost through the year. Changes in the food supply and success of the nest is probably indicated more by the number of reproductives produced in the autumn than in the population of worker ants.

Pathology. Three categories of tree failure were recognized: root failures, stem failures, and earth failures.

Seventeen out of the twenty-seven fallen trees studied were classified as root failures with the remainder falling into the other two categories. White stringy rot was the most commonly encountered decay with 24 of the 27 trees showing this dccay in the failure zone. A brown cubical rot was also seen in the failure zone of 10 of the fallen trees but it usually was not as extensive as the stringy rot. An average of 60% of the failure zone of the 11 root failures measured to date was in an advanced stage of decay and in some cases, more than 70% of the failure zone provided virtually no structural support (extent of decay measured, where possible, from photographs of the fallen sequoias). Carpenter ant galleries were visibly associated with decay in the failure zone of 10 of the 27 trees. Nineteen of the twenty-seven study trees possessed extensive fire scars. Of these, 15 fell on their fire scar side.

Isolations. Together with the field observations, isolations were made (where possible) from decayed wood collected from fallen sequoias in order to identify the fungi responsible for the various types of decay visible in sequoia sapwood and heartwood. Thirty groups of isolates were identified from these isolations, nine of which were Basidiomycetes. The decay fungi isolated connot be interpreted as being indicative of all the fungi associated with decay in sequoia sapwood and heartwood, nor can they be accurately interpreted on a quantitative basis mainly because of the subjective manner of isolation. For example, the fact that *Poria albipellucida* was isolated from only 4 of the 27 fallen trees does not indicate that this fungus was not also present in the other 23 fallen trees. Contamination, inability of some decay fungi to compete with other decay fungi in culture, sampling methods, as well as other problems, make quantitative interpretation of the isolations of decay fungi difficult. Consequently the data about the fungi associated with decay of sequoia sapwood and heartwood must be interpreted more on a qualitative basis.

Soil block tests were conducted on eight of the nine Basidiomycetes to determine their capacity to decay sequoia heartwood and sapwood. This capacity to decay wood under laboratory conditions was determined by following the procedures outlined in ASTM Standard D2017 (1970) with the following exceptions: (1) Test specimens were selected from one tree to reduce variability. (2) Sugar pine sapwood was used for the reference blocks.

Results. Six of the nine Basidiomycetes are white rot fungi, three are presumably brown rotters. *Polyporus versicolor*, *Stereum hirsutum*, and *Poria albipellucida* were the most virulent wood destroyers of giant sequoia sapwood in soil block test. *Fomes annosus* showed a slow rate of sapwood decomposition in soil block test.

Stereum hirsutum was the only fungus to cause visible decay of sequoia heartwood in soil block test.

Fomes annosus and *Poria albipellucida*, both white rotters which cause a laminated to stringy type of decay, were the most commonly encountered fungi on fallen sequoias. It is probable that these two fungi are largely responsible for the stringy to laminated rot commonly seen in the failure zones of fallen sequoias.

Strength Tests. A toughness test, following ASTM Standard D143-52, was run on discolored and non-discolored giant sequoia heartwood from the failure zone of one old-growth stem failure. The wood in the failure zone was noticeably weakened by advanced decay, predominantly a stringy rot, and by carpenter ant galleries. Discolored wood was associated with the advanced decay, but it was also observed around carpenter ant galleries. Subsequent microscopic examinations revealed that the discolored wood was in an incipient stage of decay.

The toughness test was run on three categories of sequoia heartwood: (1) non-discolored heartwood, (2) mixed discolored heartwood (discoloration only occurred in parts of the test specimen, and (3) darkly discolored wood. It was found that: (1) Toughness of discolored wood (caused by incipient decay) was not significantly different from that of non-discolored or mixed discolored wood, and was comparable to the published values for old-growth sequoia heartwood (Cockrell 1971). (2) Toughness of old-growth giant sequoia is very low in comparison with that of coast redwood or ponderosa pine. (3) All test specimens showed a very brash failure (a type of break which is commonly seen in the failure zones of fallen sequoias).

Publication

Piirto, D. D., J. R. Parmeter, Jr., and F. W. Cobb, Jr. 1974. *Fomes annosus* in Sequoia gigantia. *Plant Dis. Rep.* 58:478.

FUTURE PLANS: Future plans for this project were submitted in a proposal to the Research Biologist, Sequoia-Kings Canyon National Park, November 1974.

# # #

GEOLOGY OF KINGS CANYON NATIONAL PARK
SKC-N-5a

INVESTIGATOR: James G. Moore
U. S. Geological Survey

SUMMARY OF PROGRESS: During the summer of 1974, 2 weeks were spent in the Monarch Divide region and final mapping and sampling of the Marion Peak quadrangle was completed. This quadrangle has been compiled and is now being revised after review. It will be published in the U. S. Geological Survey geologic quadrangle map series. Field work for the summer of 1975 is planned for the northern parts of the Mount Whitney and Tipple Divide Peaks quadrangle. A field trip by scientists of the U. S. Geological Survey is planned for the spring of 1975 up highway 180 to Cedar Grove. I have replicas of the fossils found near Boyden Cave, and interesting samples of orbicular rock found near Volcanic Lakes and Ranger Meadow which may be of use for park collections. This material is described in publications previously submitted.

# # #

FACTORS IMPORTANT TO MANAGEMENT OF MOUNTAIN MEADOWS
SKC-N-17a

INVESTIGATOR: P. Zinke
University of California, Berkeley

SUMMARY OF PROGRESS: Analyses of chemical properties and field storage quantities of elements in vegetation and soil of mountain meadows in Sequoia-Kings Canyon National Parks have been completed to include carbon, nirtogen, calcium, magnesium, potassium, sodium, iron, manganese, zinc,and phosphorus, as well as pH, and bulk density. These data are now key punched and calculations of total storage of materials and capacities for storage calculated for the survey of backcountry meadow soils and vegetation made in cooperation with the Pacific Southwest Forest and Range Experiment Station. The data are available in microfiche form from the principal investigator. Their main utility will be in judging the capacity of mountain meadow soils for cropping of forage by backcountry park trains, and in the determination of the capacities of meadows to receive and process effluent from sanitary facilities established in intensive-use sites. The breakthrough points of these meadow soils for such elements as phosphorus and nitrogen and their abilities to store and process organic detritus without detrimental vegetative changes are the current objectives of this study.

Application to problems such as those at Tuolumne Meadows is probable.

# # #

THE KAWEAH PEAKS PLUTON AND ITS RELATIONSHIP TO THE AGE OF THE KERN CANYON FAULT

INVESTIGATOR: John L. Burnett

SUMMARY OF PROGRESS: The project has been completed and a manuscript submitted to the California Division of Mines and Geology for publication. A copy will be submitted as soon as publication is completed.

Results indicated that the Kern Canyon fault formed very early in the history of the Sierra Nevada. The fault was intruded by one of the last pulses of granite that formed the range.

# # #

PRELIMINARY STUDY OF THE SIERRA NEVADA BIGHORN SHEEP

INVESTIGATOR: John Wehausen
University of Michigan

SUMMARY OF PROGRESS: The primary purpose of this study was to determine the feasibility of an intensive study. This hinged largely on whether it would be possible to locate a sufficient number of sheep and whether their habits were sufficiently predictable to find them easily. This was found generally to be the case for the Mount Baxter herd, the only one studied. Ranges of spring use were determined to be the upper reaches of winter range canyons, and migration into the summer ranges apparently did not occur until the latter half of June. In the summer range, location of males was highly predictable, their habitat being certain canyon-bottom meadows. Few females were observed in the summer range but they appear to utilize largely the high rocky ridges and mountain tops. In this high rocky habitat, the flower heads of two species, *Polemonium eximeum* and *Hulsea algida*, were noted to make up the majority of the forage consumed by sheep. In the canyon-bottom meadows where rams were observed, *Carex exserta* and *Juncus parryi* appear to be the two most important forage species but in this habitat considerably more variation is available in forage species.

The writing of a research proposal for an intensive 2-year study on these sheep is presently in progress.

# # #

SIERRA CLUB IMPACT STUDIES

INVESTIGATOR: Tom Harvey
San Jose State University

SUMMARY OF PROGRESS: Third year (second resurvey) of large (64 person) trip study. During summer of 1972 the large trip took a loop trip from Cedar Grove to Marion Lake and back. Wood use, campsite use, before and after photos were taken and waste disposal were observed. In 1973 and 1974 photo sites were revisited, latrines excavated, campsite observed, and recovery of vegetation noted.

Significant findings are that, on a per person basis, large groups such as this one have less ecological impact than small groups. However, the fact that large groups often have stock and are sociologically unacceptable by most wilderness users probably overrides their lower ecological impact.

# # #

A COMPARISON OF THE ALGAL GROWTH POTENTIAL AND NUTRIENT LEVEL OF FOUR LAKES: HEATHER AND TAMARACK IN SEQUOIA PARK AND ARROWHEAD AND BIG BEAR IN SAN BERNARDINO MOUNTAINS

SKC-N-36

INVESTIGATOR: Gary J. James
University of California, Irvine

SUMMARY OF PROGRESS: The second summer of work at Heather and Tamarack lakes has been completed. Both lakes have been plumbed and rough maps showing the depth contours were submitted earlier. Algal assays, nutrient concentrations, and coliform counts were made on both lakes throughout the past summer season.

Different levels of productivity, nutrient concentration, and coliform counts were recorded in both lakes with Heather showing a consistently higher level of all of the above. The difference between the two lakes, while not analyzed statistically, appears to be insignificant.

It would appear that, while human usage may contribute somewhat to the higher level of nutrients and productivity in Heather Lake, natural nutrient sources may be just as significant. Such things as air pollution and precipitation may add significantly to the nutrient loads of the lakes.

It further appears that the amount of visitation to Heather, while considerably more than at Tamarack, does not affect the water quality in the lake to any great extent. Coliform levels are extremely low and the natural recycling processes of the lake seem able to adequately handle the nutrient input derived from human visitation.

# # #

PUMA SURVEY

INVESTIGATOR: C. Koford

SUMMARY OF PROGRESS: As explained in a letter from O. L. Wallis (27 November 1973, ref: N22 (WR) PSN), this project is a statewide, 3-year survey. In areas favorable for finding puma tracks on roads and trails, we can estimate the numbers, distribution, and size-classes of the pumas from counts, measurements, and individual identification of tracks. Although none of the major study areas are on NPS lands, for comparative purposes I plan to survey puma tracks on suitable trails and roads in Sequoia National Park for a few days in 1975 when tracking conditions are optimal. The times and places of survey will depend largely on information provided by park personnel. One prospective site is the Old Colony road during late summer when dust is well-developed, or in winter shortly after a light snowfall. Specific suggestions are needed from park personnel.

# # #

SOIL FAUNA STUDIES

INVESTIGATORS: Douglas W. Price) University of California, Berkeley
Gerald S. Benham, Jr.)

SUMMARY OF PROGRESS: Studies in a Sequoia Big Tree Grove at Whitaker's Forest concern vertical distribution patterns of soil-inhabiting insects, mites, collembolans, and other arthropods. Knowledge of these patterns is essential in determining sampling depth requirements for all types of research projects involving the soil fauna. Also, since almost nothing is known about the characteristics of the subterranean fauna, e.g., species composition, population densities, maximum depths of occurrence, influences of soil moisture, and other environmental factors, the study is providing information of fundamental biological importance.

Sampling began in December 1973 and will continue until June 1975. To date, seven samples have been taken. Each consists of a standard volume of litter, humus, and mineral subsoil. Samples are taken from the sides of an exposed soil profile obtained by digging a pit approximately 5 ft deep on each sampling date. The mineral subsoil is sampled to a depth of 48 inches at 3-inch intervals. This provides a continuous series of subsample units forming a vertical column on the profile.

This work at Sequoia National Park is a part of a project involving similar studies in a pine forest habitat near Grass Valley and in several agricultural fields in the San Joaquin Valley. Although the fauna at Grass Valley and in the San Joaquin Valley is basically subterranean in character, the fauna at Whitaker's Forest is concentrated near the surface, primarily in the litter and humus layers. Seasonal changes in these patterns are being detected in all sites studied. At Whitaker's Forest, certain components of the fauna occur consistently at lower levels in the profile. Some of these are undescribed species, and some belong to little-known arthropod groups.

Soil animals, especially those in the litter and humus, are ideal candidates for biological indicators in studies designed to detect and assess various kinds of environmental stress. Our data from forest habitats can be used to compare faunal characteristics of undisturbed habitats with those from variously disturbed study sites.

# # #

KAWEAH RIVER STUDIES
SKC-N-19

INVESTIGATOR: Maurice Zardus
National Park Service

SUMMARY OF PROGRESS: In the summer of 1973 fish habitat evaluation was conducted and beginnings were made on fisherman use study, fish population study, and invertebrate populations and water temperature monitoring. Water temperatures were studied, specifically how the temperature regime is affected by a diversion of water.

As a result of 1973 work, recommendations were made for increased flow. The work of 1974 indicates that diversion increases water temperatures. During the next 10 years for which the Kaweah project is expected to operate under special use permit, the following studies should be accomplished: (1) additional temperature monitoring, (2) creel census, (3) recreational use measurements, (4) algae growth and related water quality, (5) aerial photography for comparison of flow levels, (6) invertebrate population analysis, and (6) competition in fish populations.

# # #

BLACK BEAR ECOLOGY
SKC-N-31

INVESTIGATORS: Marshall White) University of California, Berkeley
Michael Walraven)

SUMMARY OF PROGRESS: The work for the first summer is complete. A summary of the progress to date is being prepared and will be submitted during January 1975. The initial phase of this study emphasized capture, marking, and release of bears in several locations in Sequoia National Park. Additional activities included observation of bears, collection of bear scat, habitat evaluation, and assistance with the ongoing park bear-management program. Twenty-five bears have been handled to date.

We recommend continuing this study in accordance with the initial proposal. We are planning to initiate the 1975 field season in the spring as the bears emerge from hibernation.

# # #

GRANITIC PLUTONS

INVESTIGATOR: James Chen
University of California, Santa Barbara

SUMMARY OF PROGRESS: The first stage of this project, sample collecting, was carried out before the end of November 1974. Rock specimens, weighing 10-20 pounds, were collected from 70 locations in the Sequoia and Kings Canyon National Parks.

Most of the samples were collected from four zoned plutons. These four units make an interesting pattern; the Big Meadow pluton intruded the Giant Forest pluton, then the central area of the Big Meadow pluton was intruded by the Weaver Lake quartz monzonite, and finally the small alaskite bodies. The oldest rock is chiefly a granodiorite, it is intruded by a granodiorite-quartz monzonite, which is in turn intruded by a quartz monzonite.

Preliminary studies of the zircon ages of the Giant Forest pluton and the Big Meadow pluton were carried out. The U-Pb ages of one sample of the Big Meadow pluton collected on road-cut of General Highway near the Stony Creek Campground are concordant:

Pb^{206}/U^{238} age = 67.99 MY (million years),

Pb^{207}/U^{235} age = 68.12 MY,

and Pb^{207}/Pb^{206} age = 73 MY

These data indicate that the Big Meadow Pluton was emplaced at about 68 million years ago (geological time scale--Cretaceous).

The same kind of study on one rock of the Giant Forest pluton collected near Bear Hill shows:

Pb^{206}/U^{238} age = 76.60 MY,

Pb^{207}/U^{235} age = 93.27 MY,

and Pb^{207}/Pb^{206} age = 544 MY

These U-Pb ages are discordant, which fall within the geological time scale of Cretaceous too.

These results are exciting, especially the discordancy of ages seen in the rocks of the Giant Forest pluton. Further studies of the rocks in the Sequoia and Kings Canyon area potentially should be helpful to an understanding of the early history of the Sierra Nevada Batholith.

# # #

GOLDEN TROUT RESEARCH

INVESTIGATOR: Graham Gall
University of California, Davis

SUMMARY OF PROGRESS: We have completed the analysis of four populations sampled from the Little Kern River basin, and three populations from the Upper Kern River basin. The results strongly suggest that the endemic subspecies of golden trout, *Salmo aguabonita whitei* Evermann, of the Little Kern basin remain only in the upper portions of Soda Springs Creek and Deadman Creek. Fourteen additional samplings were made this past summer and the results are now being tabulated.

A meeting is planned for April 1975 between ourselves, the Department of Fish and Game, and the Forest Service at which the results of this year's work will be discussed. Recommendations regarding future courses will be discussed at that time.

# # #

SARCODES

INVESTIGATOR: John W. Taylor
University of California, Davis

SUMMARY OF PROGRESS: Root samples of *Sarcodes* and *Pterospora* have been fixed and embedded for thick and thin plastic sectioning. There are no significant findings yet as the researcher is still attempting to master the technical problems associated with thin sectioning. The plans set forth in the abstract of 22 August 1974 still seem reasonable.

# # #

GENETICS OF GIANT SEQUOIA

INVESTIGATOR: Lauren Fins
University of California, Berkeley

SUMMARY OF PROGRESS: This past summer I collected giant sequoia cones in six of the groves in the parks. The major collection is from the Redwood Mountain Grove. Seed from these cones will be used in genetic analyses on both a biochemical level and in clonal outplantings. Some of the seed will also be stored for gene conservation.

We are beginning to look at giant sequoia as a possible addition to the mixed conifer timber growing resource of the Sierras. To date, no one has assessed the inherent variation in the species. The collection I made this summer will serve as a basic resource to investigate the genetic variation throughout the natural range of the species. Early biochemical work will begin this winter (1975) and the seedlings for future clonal outplantings will also probably be germinated sometime this winter or early spring.

The groves preserved in Sequoia and Kings Canyon will undoubtedly play a major role in the current investigation. Any future findings will be made available as they become known.

# # #

1974 MEADOW INVENTORY

SKC-N-39

INVESTIGATOR: Steve DeBenedetti

SUMMARY OF PROGRESS: Field investigation has been completed as planned. About 25% of the voucher collection has been keyed. The general format for individual meadow reports has been generated and I am at work on them now. Specific findings will be delimited in particular meadow reports. General findings include: (1) The appearance of the vast majority of meadows surveyed has improved since 1958. The improvement is visible in terms of the status of the use complex associated with the meadows and in terms of the integrity of the vegetation. This improvement is the result of a generally positive management perspective. (2) This is not to say that both general and particular problems are non-existent. Nor is it to imply that manipulative management provides any but a short-term and cosmetic solution to several problems (lodgepole encroachment). (3) Removal of lodgepole pine from meadow ecotones is unsuccessful as a long-range meadow restoration procedure. (4) The age class distribution of invading lodgepole pine observed by Sharsmith was recognized in our study and warrants further study. (5) Backcountry use patterns must be reexamined in light of trail head limitations. (6) Serious consideration should be given to the permanent placement of a backcountry ranger in the Granite Basin-Kennedy area.

I believe that the individual meadow reports will become valuable references for managers and future researchers. Many important meadows remain uncharted. Future consideration is warranted. Recharting of some of the meadows surveyed in 1973 to bring them to quantitative parity with the survey of 1974 might prove beneficial. Resource inventories should be expanded to include such critical management focii as backcountry camp areas, trail conditions, fisheries, and wildlife.

# # #

NATURAL BURN RESEARCH
SKC-N-11

INVESTIGATOR: Jim Villaponteux
University of California, Berkeley

SUMMARY OF PROGRESS: A group research project was employed to gather background information on the Let-Burn Policy's fulfillment of the National Park Service's goal to conserve the natural state for enjoyment now and in the future. This was accomplished by examining the community dynamics of the area, with and without fire. Evidence from stand-age analysis and other feasible methods such as stability and community diversity was examined in this regard. An economic impact analysis of the Let-Burn Policy was also undertaken by our study.

We are intending to approximate the natural state by determining the area's pre-European man condition. We want to determine the post-burn state of the area and hypothesize what will happen successionally with and without a continual fire input.

Our study focuses primarily on the Sugarloaf Valley in Kings Canyon National Park. In the summer of 1973, the South Sentinel Fire occurred which burned approximately 2500 acres on the north side of Sugarloaf Creek. We conducted a preliminary survey in July 1974, with which we delineated three habitats on the basis of species composition and intensity of ground cover. These habitats are: (1) Open--consisting of Jeffrey pine (*Pinus jeffreyi*) and lodgepole pine (*Pinus contorta* spp. *muricata*), (2) Closed--consisting mainly of white fir (*Abies concolor*) with some Jeffrey pine and lodgepole pine present, and (3) Brush--consisting mainly of Manzanita (*Arctostaphylus patula*) with some white fir, Jeffrey pine, and lodgepole pine.

SIGNIFICANT FINDINGS: Allowing naturally ignited fires to burn has resulted in net savings to the fire management budget in Sugarloaf Valley. No significant differences could be shown in the water quality factors examined between burned and unburned watersheds. Fire had differential effects on the three habitats studied. The open habitat exhibited the least change in overall vegetation responses to fire. Moderate changes were observed in the closed habitat. The brush habitat showed the greatest responses. Ground fuels in the brush habitat respond most rapidly to weather changes. These fuels have the highest burning potential during dry conditions. In general, lodgepole pine had a higher survival rate than Jeffrey pine, while white fir exhibited the lowest survival rate of the tree species studied.

Animal responses to fire was often immediate, with birds, deer, and squirrels observed feeding over areas burned the same day. Some aerial insectivores, such as swallows and swifts, seemed to be attracted to smoke. Even so, fire will mainly affect wildlife carrying capacity by habitat alterations. The differences in bird and small mammal populations were most dramatic between burned and unburned brush habitats. In general, the burned areas in brush supported major invasions by seed-eating birds. Midsummer deer mouse populations were higher on the burned brush portions of the valley.

The burned and unburned portions of the valley differed in the heterogeneity, composition, and diversity of vegetative communities. These measures were higher on the burned habitats.

During our study this season (1974), another fire burned the previously unburned portions of Sugarloaf Valley--the Comanche Fire. Our unburned study sites are now burned. This will allow us to return next year to obtain more accurate information on reintroduction of fire into this environment.

# # #

FUR-BEARING MAMMALS SURVEY

INVESTIGATORS: A. Starker Leopold)
Marshall White) University of California, Berkeley
Phil Schempf)

SUMMARY OF PROGRESS: The initial phase of this project has been completed. Contract CX-8000-3-0025, with the NPS, Western Region, was fulfilled by a report, *A survey of the status of seven species of carnivores on National Park Service lands in California*, submitted in July 1974. Concurrent with this survey we have reviewed the status of these species on U. S. Forest Service and other lands in the mountains of northern California. This broader survey will be published during 1975, and copies will be made available to the National Park Service.

Future plans include more detailed field studies of these species on National Park Service lands. We plan to submit such a proposal for additional research during 1975.

# # #

SPATIAL PATTERN AND SUCCESSION WITHIN A MIXED CONIFER--GIANT SEQUOIA FOREST ECOSYSTEM

SKC-N-34

INVESTIGATOR: Thomas M. Bonnicksen
University of California, Berkeley

SUMMARY OF PROGRESS: The thesis is in the final stages of preparation, i.e., approximately 1 month remains before distribution. A theory will be advanced to account for the patchiness of the vegetation and its implications to the dynamics of the forest type.

# # #

FIRE IN THE MIXED CONIFER FOREST
SKC-N-6

INVESTIGATOR: David J. Parsons

OBJECTIVES: To study the role of fire in the mixed conifer forest communities of Sequoia and Kings Canyon National Parks. Preliminary emphasis is on an investigation of the composition and age structure of representative stands of the different vegetative types found within the mixed conifer forest zone of the parks. Knowledge of both present species composition and age distribution will provide the background information necessary to recreate the vegetative mosaics which existed when white man first entered on the scene. It will provide a basis for understanding both the present nature of the various mixed conifer forest types as well as what changes have occurred under the fire suppression policies of the 20th century. This information should be of great value to resource managers for use in effectively planning future burning programs so as to best reflect the pristine vegetative mosaic of the mixed conifer forest.

METHODS: Representative examples of the different forest types within the mixed conifer zone have been selected. Replicate plots of 0.10-acre in size have been distributed through each type and preliminary measurements made. Maps identifying and locating each tree, clump of brush, and other landmarks have been made. Photographs typifying each site will be taken. Detailed observations will be made for each plot of soils, litter, fuel accumulation, and herbaceous vegetation. For each individual tree, measurements will be made of diameter, height, and age. This information will be summarized for each plot and then again for each forest type in order to provide a composite picture of the vegetation dynamics in each type. Age structure will be extrapolated backwards to obtain information on past species composition. Where applicable, attempts will be made to correlate this information with known fire and weather records as well as to learn something of the frequency of past fires in the different types. Comparison between types will be made to see if there are similar trends in vegetative change or whether some types are more subject to change under a fire suppression regime than are others. Percent similarity and species composition before and after the advent of fire suppression policies (about 1890) will be calculated as an index of change.

RESULTS: To date, detailed measurements have been made only in the white fir subtype. The data has not yet been analyzed.

PLANS FOR 1975: Field efforts will be expanded into additional types. Primary emphasis will probably be given to Jeffrey pine and mixed black oak-sugar pine-white fir. If time and manpower allow, the preliminary attempt at data analysis will begin.

Publications are expected on age structure and the relationship between fire suppression and vegetative change within the mixed conifer forests of the parks.

# # #

USGS HYDROLOGICAL STUDIES
SKC-N-9

INVESTIGATOR: Bob Averett
U. S. Geological Survey

SUMMARY OF PROGRESS: We have accomplished the objectives of the program to date. In the Roaring River basin, sampling of water quality in the vicinity of wildfires was expanded to include collection of water and biological samples in the headwaters of five streams in the basin. Analysis of data obtained during the past summer is in progress. Future sampling will continue as planned except where the effects of the recent Comanche wildfire require changes.

# # #

RESTORATION OF NATURAL ENVIRONMENT IN MIXED CONIFER FOREST

SKC-N-26

INVESTIGATOR: Bruce M. Kilgore
National Park Service

SUMMARY OF PROGRESS: The general findings from this project were previously summarized in the 1972 Annual Report of the Office of Natural Science. No field work was undertaken during 1974. The manuscript *Crown Fire Potential in a Sequoia Forest After Prescribed Burning*, co-authored with Rodney W. Sando, was submitted to *Forest Science*, received editorial criticism, was revised, and resubmitted. Hopefully, publication will occur in 1975.

# # #

NATURAL FIRE FREQUENCY INVESTIGATION

SKC-N-27

INVESTIGATOR: Bruce M. Kilgore
National Park Service

SUMMARY OF PROGRESS: Previous results on this project were reported in the 1972 Annual Report of the Office of Natural Science. No field work was undertaken during 1974. The manuscript summarizing the main findings and conclusions is still being worked on in cooperation with co-author Daniel Taylor. Hopefully, it will be reviewed by the late summer of 1975 and submitted for publication by fall 1975.

# # #

THE ROLE OF FIRE IN CHAPARRAL

SKC-N-28a

INVESTIGATOR: David J. Parsons

OBJECTIVES: To study the role of fire in the Chaparral communities of the lower elevation foothill regions of Sequoia National Park. Information is needed both on historical frequency of fire in these areas and on understanding the ecological effects of fire on the plant and animal communities involved. The ultimate objective is to provide the background information needed to restore fire to its natural role in this community type.

METHODS: Historical records will be examined to help understand the past frequency of fires in this community type within the park. Field studies will be aimed at sampling biotic and abiotic characters of different age stands in an attempt to relate community structure and succession to fire frequency. Sampling will also aim at understanding the role of fire in creating the vegetative mosaics found in the foothill regions.

RESULTS: Study areas have been located on south slopes in pure chamise chaparral experiencing the following time periods since the last fire: 2 years, 16 years, 37 years, and over 50 years. Vegetative characteristics for both the herbaceous and woody vegetations have been sampled from each of these sites. The analysis of this data has yet to be accomplished. Preliminary indications show a general increase in diversity, cover, height, and vitality of the woody vegetation through the 37-year plot. The indications are that beyond this point, chamise fields begin to decrease in diversity and show a general overall senescence. As expected, the herbaceous vegetations are most diverse during the first years following a fire.

PLANS FOR 1975: All field data collected during 1974 will be analyzed and prepared in publication form. In addition, a literature and historical survey will be started to help determine the role of fire in the area before the coming of European man. Contacts will be made to the U. S. Forest Service Fire Laboratory in Riverside, California, and cooperation started in developing a program for the use of prescribed burning in the chaparral regions of the park.

A semi-popular article is currently being prepared for National Parks and Conservation Magazine. In addition, a more detailed paper on fire succession in the chamise chaparral of the park will be prepared during the coming year.

# # #

THE ECOLOGY OF MIGRATION IN WARBLERS (PARULIDAE)

INVESTIGATOR: Richard L. Hutto
University of California, Los Angeles

SUMMARY OF PROGRESS: Research during the spring and summer of 1974 was devoted mainly to orientation, i.e., feasibility of working with warblers, etc. After working in Sequoia for 2 weeks and in Wyoming for 4 weeks it was determined that warblers characteristic of the low, scrubby habitats would be best to work with. These include Yellow, Yellowthroat, MacGillivray's, Nashville, and Wilson's.

Data related to habitat selection and feeding behavior were collected and will be used in a comparison to similar measures taken in the warbler's winter habitat in Mexico this coming January-March.

# # #

SHENANDOAH NATIONAL PARK

ECOLOGY AND POPULATION DYNAMICS OF THE BLACK BEAR
SHEN-N-13

INVESTIGATOR: Jack W. Raybourne
Virginia Commission of Game and Inland Fisheries

SUMMARY OF PROGRESS: Intensive trapping efforts were conducted from April to October 1973. Ninety-seven animals, consisting of 69 males and 28 females, were tagged during this period. Trapping operations were conducted on lands of the Shenandoah National Park, George Washington National Forest, Virginia Game Commission, and private lands. Eighty-nine were captured on the Shenandoah National Park (92%) where major trapping efforts were concentrated. Aging by cementum annuli counts of bear canines and first upper premolars from 1972 and 1973 was completed.

Trapping activities from April to October 1974, resulted in the capture and marking of 61 additional bears. Laboratory aging of tooth samples is in progress.

The age range for combined sexes was 0.75-12.75 years. Average age was 4.6 years for males, 4.7 years for females, and 4.6 years for combined sexes. Females comprised 29% of the sample. Sixty-six of the animals (68%) were 4.75 years or less. Nine of 97 animals were 8.75 years or older (9%). Two of the nine animals 8.75 years or older were females (22%). Male to female ratio was 2.5:1. Males were more vulnerable to trapping than females (71% males to 29% females). Age classes up to 5.75 years were more vulnerable than older age classes. Both of these situations might well have been expected, however, males were more vulnerable in all age classes less than 5.75 years, and in most older age classes. One and three-quarter- to five and three-quarter-year-old males comprised most of the animals trapped during 1973. Trapped animals ranged in age from 0.75 to 12.75 years in 1972 and 1973.

Ages determined by cementum annuli counts from 67 hunter-returned lower jaw canines indicated similar vulnerability for male bears in the younger age classes. Male to female ratios were nearly equal in older age classes, but females comprised only one-third of the 1.75 to 4.75-year age classes. Harvested animals ranged from 0.75 to 13.75 years in the 1972 sample, and from 1.75 to 19.75 in the 1973 sample.

Thirty-three of 97 animals tagged during 1973 have been recovered (34%). Four were shot in nuisance situations by landowners and two were killed by vehicles. Hunters harvested the remaining 81%. Tagged bears averaged 13% of the legal harvest for counties adjoining the Shenandoah National Park where the combined harvest was 163 animals or 55% of the statewide total of 295.

# # #

SLEEPING BEAR DUNES NATIONAL LAKESHORE

FACTORS CONTROLLING THE POPULATION OF RING-BILLED GULLS ON SOUTH MANITOU
SLBE-N-3

INVESTIGATOR: William E. Southern
Northern Illinois University

SUMMARY OF PROGRESS: Between 1966 and 1973 the Ring-billed Gull (*Larus delawarensis*) breeding population on South Manitou has decreased from 6000 pairs to about 3000 pairs. This decline is documented by figures provided by J. P. Ludwig, W. Scharf, and G. Shugart. There has been a corresponding reduction in the land area used by the gulls from 20,000 square yards in 1966 to approximately 7000 square yards in 1973. In addition adult and juvenile mortality rates have seemed to be unusually high during the last two breeding seasons. This was particularly apparent when I visited the colony in July 1973. The availability of these facts justifies a conclusion, rather than a speculation, that this colony is in serious trouble and desertion is likely if steps are not taken to bring the decimating factors under control.

That the colony has actually decreased in size during a period when there has been a surplus of breeding age Ring-billed Gulls in the Great Lakes Region is particularly significant. Recent high lake levels have submerged some islands thereby forcing prior inhabitants to secure territories elsewhere or to remain as non-breeders. Since the South Manitou colony has not enlarged significantly during this period it appears that the environmental conditions on the island are below optimum for Ring-bills. The existing conditions not only inhibit immigration but also endanger the present inhabitants.

Finding a solution to the problem initially requires a better description of the actual problem(s) and identification of the causative factor(s). Once this is done it seems feasible to propose that a management plan be developed and implemented to produce the optimum conditions necessary for a successful Ring-billed Gull colony. If the colony is to be preserved it is essential that further reduction in population be stopped as soon as possible since there appears to be a critical minimum number of pairs (something in excess of 200) that is essential for successful nesting of this species. Apparently if the number of breeding pairs is below this figure, nesting success will be near zero (personal observations from 10 Michigan subcolonies).

Several kinds of potential problems (e.g., human disturbance, predation, plant succession, competition, weather) must be considered in addition to the present high water level of Lake Michigan, which obviously reduces the land area of the island and also eliminates some terrain suitable for gull nesting. It is unlikely that water level is the major decimating factor at this location since gulls have characteristically nested on a sandy elevation above the northeast beach area and a significant portion of this terrain is above the high water line. Identification of the other and apparently more critical factors must be accomplished prior to preparation of a plan designed to adequately modify their effects, reduce adult and chick mortality, and stabilize the colony at an optimum size.

A 2-year study is herein proposed during which a thorough analysis will identify the factors responsible for the decline (Year I) thereby providing a basis for developing a management plan (Year II) that can be applied in part during the second summer. Other portions of the plan will involve recommendations that probably will have to be implemented by National Park Service personnel during non-breeding periods (preferably fall).

During the first year I will maintain surveillance in the colony from about 15 May through 10 July and monitor a variety of factors, including: (1) the possible effects of mammalian predators; (2) the nature and extent of human disturbance; (3) the rate of, and causes for nest desertion, egg loss and mortality; and (4) the characteristics of colony areas having different nesting densities.

The South Manitou results will be compared with those from three other Great Lakes colonies that have been under study for some time, these are: (1) Calcite Colony--a mainland colony with unusually high levels of human contact; (2) Bird Island--a Lake Huron site that is severely affected by high water levels and an influx of woody vegetation; and (3) Ile aux Galets--a small Lake Michigan island that changes little from year to year with respect to human contact, and other factors that will be under consideration. The comparative approach will provide a base against which observations for South Manitou can be evaluated. This is considered necessary because one season obviously is inadequate for evaluating all of the intricacies involved in the South Manitou gull problem.

The resulting data will be used to outline procedures that may be followed to: (1) reduce mortality; (2) maintain or increase colony size; and (3) regulate human activities in or near the colony to permit use but not destruction of this resource.

During Year II, I will assist the National Park Service in implementing the preliminary aspects of the management plan prepared prior to the breeding season. Follow-up studies will then be conducted in an attempt to evaluate the applied management prodedures prior to preparation of a more detailed plan. In addition data will be provided regarding the migratory behavior of the South Manitou population and the entire Great Lakes population, longevity of Ring-billed Gulls, age structure of breeding populations, and aspects of breeding biology pertinent to management.

The South Manitou Ring-billed Gull colony is unique in the Great Lakes area because it is the only one located where human activities can be controlled, long-range habitat improvement programs conducted and other steps taken to insure survival of the colony. Many of the other colonies are on privately-owned islands, on "temporary islands" with respect to the water cycle, or at locations subject to unpredictable levels of human disturbance. Because the fate of these other colonies cannot be controlled it is critical to the survival of this species that steps be taken to maintain the South Manitou colony.

# # #

VOYAGEURS NATIONAL PARK

THE ROLE OF VIRUSES AND MYCOPLASMA-LIKE ORGANISMS IN WILD AREAS INCLUDING THEIR IDENTIFICATION AND ANALYSIS OF THEIR IMPACT ON PARK ECOSYSTEMS

INVESTIGATOR: Ernest E. Banttari
University of Minnesota

SUMMARY OF PROGRESS: Approximately 590 samples of herbaceous and woody plants were collected for the survey of plant viruses and mycoplasma-like organisms from natural plant communities on the Kabetogama Peninsula. The primary collection sites were permanently marked, 0.25-acre plots on the north and south sides of the Peninsula. However some collections were made on Neil's Point and Sullivan Bay. The individual samples were assayed at the University of Minnesota. Histological techniques, leaf-dip electron microscopy and inoculation to sensitive virus indicator plants were used to assay for viruses and mycoplasma-like organisms.

With the exception of finding a severe bunchy-top desease in *Rhus glabra*, most of the samples did not have detectable virus infection. The abnormality in *R. glabra* is prevalent at many locations on the Peninsula. Although a pathogen has not yet been identified, it appears that a mycoplasma-like organism may be involved in the bunchy-top disease. At several locations infected plants have been tagged and an attempt will be made to determine the rate and how this disease spreads.

# # #

EAGLE AND OSPREY NESTING SURVEY

INVESTIGATOR: Lee H. Grim

SUMMARY OF PROGRESS: All Bald Eagle and Osprey nesting sites located and observed in Voyageurs National Park in 1973 were censused again in 1974. Several new nesting sites of both species were located and observed during 1974 and the data pertaining to each nest were recorded on administratively confidential data sheets. This information is to be used for management practices.

Nesting success for the Bald Eagle was 0% in Voyageurs in 1974. Unseasonably cold temperatures (-30°F) combined with high winds (20-30 mph) during the incubation period appeared to be the major limiting factors for this failure. Osprey nesting success for 1974 was similar to that in 1973. Adults of both species were frequently observed during the year.

The census should continue so as to monitor the population dynamics of the Bald Eagle, Osprey, and Great Blue Herons of Voyageurs National Park. The work can proceed as in the past by using aerial observation reinforced by additional surface checks on nesting sites. The present support level and time schedule appear to be adequate at this point in time.

# # #

VEGETATION SURVEY OF KETTLE FALLS AREA OF VOYAGEURS NATIONAL PARK

INVESTIGATORS: L. C. Merriam, Jr.) University of Minnesota, St. Paul
V. Kurmis)

SUMMARY OF PROGRESS: To date, as agreed upon at the time of the contract signing, no field work has been completed due to non-availability of personnel. Background information, maps, and photographs have been obtained and field work will be completed in the summer of 1975.

# # #

UNIVERSITY OF WASHINGTON

PROGRESS REPORT: JULY-DECEMBER 1974

SUMMARY OF PROGRESS: John S. Burch. A preliminary investigation was begun of the existing research on people in parks, Their sociological and demographic characteristics were of particular importance. An annotated bibliography was begun on research pertinent to people in the Olympic National Park and the surrounding vicinity as well as Point Reyes National Seashore and its locale. Upon the completion of this bibliography a substantial step in forming a research proposal will have been taken. Another important step in determining a research proposal was taken by reviewing the literture and methodology of social area analysis. Several meetings with Donald R. Field and Rabel J. Burdge (visiting professor of sociology from the University of Kentucky at Lexington) were held, discussing the application of social area analysis to a regional framework. The implications of such a methodology for management decisions involving a need to know "who uses" parks and "why" are significant. Review and general familiarization with the North Pacific Border Study was also begun. Three classes (Demography and Ecology, Wilderness Management, and Dendrology) were completed during the autumn quarter.

Harriet H. Christensen. Planning is ongoing under the auspices of the Sociological Studies Program of the National Park Service to study leisure patterns of residents in Washington, Oregon, and Idaho. The probability sample may include 4000 people and be conducted through a combination of telephone interviews and mail questionnaire techniques. Beginning date is not decided upon. However, field work will probably begin in the summer of 1975 with questionnaire distribution in the fall of 1975. Additionally, a grant proposal will be submitted to the Water Research Center, State of Washington by January 1975. This proposed 2-year study, sponsored jointly by the National Park Service and the Water Research Center, will investigate further the sociological dimensions of water-based recreation. This effort will be a part of the broader study mentioned above. Courses undertaken during this period included Urban Community (Dr. Guest); Inference, Measurement and Data Analysis (Dr. Blalock); and Wilderness Management and Preservation (Dr. Hendee). Extensive readings were pursued in the areas of wilderness philosophy, allocation, politics, classification, and management. Additionally, time was set aside this quarter for readings in the area of fire ecology. A portion of this review period was spent on a secondary analysis of deviant behavior in well-developed campgrounds. The intent is to focus in on camper tolerance with regard to litter, noise, nuisance behavior, etc. Specifically, what is the relationship between tolerance and family life cycle, age when first camped, type of camping preferred, residence, etc.? Work will continue on this project next quarter--completion due date is March 1975. Winter quarter 1975 course work will include the second half of Inference, Measurement and Data Analysis; Study Design (Dr. Costner); and Recreation Research (Dr. Clark). Work will continue on the three-state study sponsored by the National Park Service, the Water Research Center problem, and the final problem identification for the dissertation requirement. The latter will be on human dimensions in water-based recreation but specifics have not been identified.

David O. Duggins. The 1974 field season was spent in Glacier Bay, Alaska, with most work centered at Torch Bay on the outer coast of the monument. During the months of June, July, and August a preliminary survey of the marine intertidal invertebrates was completed, concentrating on patterns of abundance and distribution. In addition to species list generated by this survey, this aspect of our work documented range extensions for several intertidal species. Experiments begun in June provided data on successional events to the end of July; these experiments are necessary in order to assess the effects of seasonal variation in larval recruitment. Size distributions, preliminary fecundity measurements, and predator manipulation experiments occupied a major portion of our time in July and August. Before returning to Seattle a cursory survey of intertidal invertebrates found in the headwaters of the bay was undertaken. Returning to school in October, I enrolled in my fiest quarter of graduate study, attending classes in statistics, dendrology, and seminars in current ecological topics. The written report on the summer's field work was completed by mid December with copies sent to Fred Dean, University of Alaska; Ian Worley, University of Vermont; and Greg Streveler, Glacier Bay National Monument. James Quinn, a graduate student in zoology, and I completed a grant proposal in November which we submitted to the Institutional Fund Committee of the Graduate School, University of Washington. This proposal represents the direction of our future field work and Ph.D. theses. The field report and proposal have been submitted.

W. Frederick Stevens. Field research during the first half of FY 1975 ended on 30 August 1974 after 8 continuous months of study in San Juan Island National Historical Park. Investigations into the biology of the European rabbit (*Oyrctolagus cuniculus*) on San Juan Island were directed toward refinement and confirmation of data collected from 1 December 1972 through 30 June 1974. Briefly, major projects concluded are detailed mapping of the 48-ha prairie study area, extensive microhabitat description (quantitative), productivity and phenology anlaysis, and ascertainment of the rabbit's breeding and population biology. This is in addition to standard biological methods of census, photopoint, mark-and-recapture, autopsy, and micro-climatology. Writing of the final report commenced on 1 September 1974 and is expected to be completed about 1 April 1975. Planned monthly 3-day field trips to San Juan Island through April 1975 ensure continuity in seasonal population parameters and extrinsic factors. The tent camp in Jakel's Lagoon was broken down and all equipment and personnel moved into winter quarters provided by the park.

# # #

WIND CAVE NATIONAL PARK

BULL BISON BEHAVIOR AT WIND CAVE NATIONAL PARK

INVESTIGATOR: Stephen J. Petersburg
Iowa State University

METHOD: Most observations of bison were initiated from a vehicle driven along highways and fire trails. The ages of the bison were estimated on the basis of physical features, particularly shape of hairdo and bell and general body proportions. The reception and identification of telemetry radio signals provided the primary means of identifying individual bulls. (Some bulls could also be identified with color coded collars.)

DISCUSSION: Bison are segregated into cow groups, bull groups, and lone bulls. Some interaction between groups occurs throughout the year. Bull groups range in size from 1-15 and are led by older bulls. Lone bulls are voluntary isolates which frequently join other bulls. Antagonistic behavior and displays of dominance were observed. Submission is signalled by turning away from one's opponent or by suspending antagonistic behavior to graze. Aggression consists of over antagonistic actions directed toward conspecifics and is most intense during rut. Pawing, horning, wallowing, and discordant noises serve as threat in antagonistic context. Fighting consists of mock battles and intense combat. Severe injuries were inflicted during intense combat. Sexual investigation of cows was the most frequent sexual behavior pattern performed by bulls. Tending bonds are the relationships observed between individual bulls and cows during rutting activities. The rut extended from 20 July through mid-August. The post-rut is initiated by a major efflux of older bulls from herds.

All bison preferred prairie and meadow habitats. Definite movement patterns by bulls were evident as they abandoned early summer ranges to join cow-calf herds, traveled with them over the typical herd range and then left the herd as rutting activity subsided.

Vocalization of bulls was infrequent except for roaring during rut. Play activities were performed mainly by younger bulls. Bulls groomed themselves by wallowing and rubbing. Two hundred eighty-nine wallows were measured in 1970. Forty rub trees were surveyed in the same year.

Bison can travel over almost any terrain. Gaits include walking, trotting, galloping, bounding, and jumping. Ingestive behavior includes grazing, browsing, rumination, and drinking. Bull bison rested both standing up and lying down.

# # #

WIND CAVE NATIONAL PARK GRASSLAND ECOLOGY

INVESTIGATOR: F. Robert Gartner
SDSU Agricultural Research and Extension Center

INTRODUCTION: Prescribed burning was utilized to reduce herbaceous fuels and develop a fire break in the eastern portion of Wind Cave National Park.

SUMMARY OF PROGRESS: (1) Prescribed burning in the grassland area of Wind Cave National Park greatly reduced total fuels and created natural firebreaks suitable for controlling wildfires. (2) Prescribed burning in grasslands similar to those studied can be safely accomplished with proper equipment and

and adequate manpower under a wide range of fuel moisture and climatic conditions. (3) Burning should be conducted in late winter or spring when air temperature is 70° or lower, relative humidity 30% or more, and wind speeds not greater than 10-12 mph. Higher wind speeds are acceptable if burning is conducted toward an existing road. (4) Late summer or fall burning may be necessary in some areas of the park or because of labor availability at that time of year. However, burning at this season should only be done when seasonal precipitation is above normal. (5) Moisture content of the mulch layer should be sufficiently high so as to prevent total combustion of this component when burning at any season, but especially in fall or winter. (6) Sufficiently large acreages should be burned in order to avoid overuse of regrowth vegetation by park ungulates. (7) Prescribed burning can be used to attract ungulates to key areas for convenient viewing by park visitors. Nearly all the rangeland within the park is in excellent range condition, and populations of native ungulates appear to be in balance with annual forage production. For these reasons no difficulty was anticipated in sampling forage yields. Furthermore, the burned area at each study site totaled less than 0.6 acre, while the total area burned was about 295 acres. Thus, it was postulated that if animals were attracted to the burned areas, subsequent grazing use of the study plots would be negligible since they comprised only a small percentage of the total area burned (less than 1%). Unfortunately this supposition was grossly incorrect, and forage yields sampled 16 August 1974 were greatly modified by utilization by bison and, to a lesser extent, by elk, antelope, and deer. (8) Spring burning, in particular, appeared to stimulate the production of western wheatgrass, the major component of most range sites. Burning at this season should be done before new growth is initiated in spring. (9) Burning in fall or spring reduced the density and abundance of the annual grass, Japanese brome, thereby reducing the competition for soil moisture and nutrients with native vegetation. (10) Burning in fall and winter may reduce soil moisture in spring, especially when winter and spring precipitation is below normal. (11) Continuing studies are necessary to determine the frequency at which park grasslands can be burned without diminishing their quality or productivity. These studies, of necessity long term, should monitor soil moisture, temperature, and chemical changes, vegetation composition changes with various burning frequencies, and density, height, and frequency of key plant species as an indicator of plant vigor.

# # #

YELLOWSTONE NATIONAL PARK

ACOUSTIC-MAGNETIC STUDIES, YELLOWSTONE LAKE
EARTHQUAKE MONITORING, YELLOWSTONE-HEBGEN LAKE REGION

INVESTIGATOR: Robert B. Smith
University of Utah

SUMMARY OF PROGRESS: The NSF-sponsored University of Utah-University of Wisconsin-Milwaukee Yellowstone Lake project was completed August 1974. New data taken in 1974 included 45 km of seismic reflection profiles, 10 piston cores for paleomagnetic analysis, 50 km of seismic refraction profiles, detailed magnetic and high resolution seismic profiles in Mary Bay, and 22 heat-flow measurements. The data indicate that two sedimentary basins of different structural and depositional environments exits; one in West Thumb and one in the main body of Yellowstone Lake. Both sedimentary basins appear to be underlain by two high-temperature layers; the main Lake basin by a shallow layer of granitic composition and West Thumb probably by a shallow, unstable, water-filled layer. The data support the concept of the Yellowstone caldera, which is defined by variations in structure and thermal properties across the east-trending caldera boundary between Flat Mountain Arm and Signal Point.

A comparison between the pseudo-gravity map obtained from aeromagnetic data and the actual gravity data indicate two masses of material whose temperature is above the Curie point (525°C) and shallower than 10 km beneath the northeast and the southwest ends of Yellowstone caldera. Seismic data from previous years together with these data support the hypothesis of an upper-mantle hot spot beneath Yellowstone.

We are presently proposing geodetic and additional seismic measurements be taken in Yellowstone to determine regional strain rates and the limits of earthquake activity associated with the Yellowstone hot spot.

# # #

STUDY USING X-RAY DIFFRACTION CRYSTALLOGRAPHY OF THE CHANGES IN VOLCANIC RESIDUES WITH TIME AND INTERACTION WITH FOREST DECOMPOSITION PRODUCTS

INVESTIGATOR: Ivan G. Holmes
Loma Linda University

SUMMARY OF PROGRESS: Some 280 samples taken from the volcanic layers north of the Specimen Creek area have been ground and powdered for diffraction scans. Approximately 60 diffraction scans have been completed. Detailed data analyses have just begun.

The study thus far has emphasized the sampling of the vertical layering changes. A detailed sampling of several different parts of the same horizontal zone(s) should be made to determine the uniformity of the volcanics.

# # #

SYSTEMATIC INVESTIGATIONS OF INDIGENOUS TROUTS OF NPS

YELL-N-70

INVESTIGATOR: Robert Behnke
Colorado State University

SUMMARY OF PROGRESS: During 1974, two graduate theses were completed on the systematics and zoogeography of the endemic cutthroat trout of the northern Rocky Mountain region. The taxonomy of the Westslope cutthroat trout, the Yellowstone cutthroat trout, and the cutthroat trouts of the Snake River and upper Missouri River was clearly defined for the first time. It was found that the name *Salmo clarki lewisi* applies to the native trout of both the upper Missouri River and the upper Columbia River. The Yellowstone cutthroat trout is most closely related to the large spotted cutthroat trout in the headwaters of the Snake River and of the Bonneville basin. A fine-spotted cutthroat trout also occurs in the Snake River and represents an undescribed subspecies. The area comprised by Yellowstone and Teton parks contain three distinct varieties (subspecies) of native cutthroat trout, the upper Missouri variety (*S. c. lewisi*), the Yellowstone and large-spotted Snake River variety (*S. c. bouvieri?*) and the fine-spotted Snake River cutthroat (*S. c.* subsp.).

Completion reports and recommendations will be written in spring 1975.

# # #

BALD EAGLE AND OSPREY POPULATIONS; STATUS, TRENDS, AND ECOLOGY
YELL-N-66

INVESTIGATOR: Robert L. Eng
Montana State University

SUMMARY OF PROGRESS: The final report for this project covering all three field seasons is nearing completion. This report will include the population data and recommentations for maintenance of these data on a monitoring basis.

# # #

HUMAN WILDLIFE INTERACTIONS IN YELLOWSTONE NATIONAL PARK
YELL-N-72

INVESTIGATOR: H. D. Picton
Montana State University

SUMMARY OF PROGRESS: Backcountry use permits, communication center records, and mail questionnaires were again used in 1974 to obtain information on the kinds and intensity of human use in the Gallatin range study area. Approximately 50% of the questionnaires for the 2 years have been returned and are presently being analyzed. Sixty-two days were spent in the field in the period 4 July to 7 October 1974. Observations of visitor use and campsites were made. Observations of wildlife species, their distribution and behavior were also made. Wildlife distribution patterns in relation to visitor use were studied by means of ground observations, three aerial flights, and 28 pellet group transects. Most of the transects were visited and analyzed six times during the summer. The distribution and movements of grizzly and black bears were of particular interest. Detailed records of bear and bear sign observations were maintained. This data plus that obtained by other researchers since 1970 will be analyzed in an attempt to determine areas and periods of high bear density in the Gallatin Range.

The data obtained during the past 2 years is presently being analyzed and organized. This data is being interpreted relative to (1) the capacity of the area to accomodate such use without lessening aesthetic or scientific values, and (2) how to regulate hiking and camping in grizzly bear habitat so that such activities are reasonably safe. It is anticipated that the final report will be completed by March 1974.

# # #

FOOD HABITS OF GRIZZLY BEAR IN YELLOWSTONE NATIONAL PARK AND VICINITY
YELL-N-74

INVESTIGATOR: H. D. Picton
Montana State University

SUMMARY OF PROGRESS: All field work and course work has been completed. In the course of two summers of field work more than 900 bear scats were collected. Additionally, collections were made from sample plots of vegetation known to represent grizzly foods. Two grizzly carcasses were utilized as study specimens.

Scat analysis is one-third complete. Chemical proximate analyses of bear food materials and scats have been completed. No analysis of preserved grizzly organs has been undertaken to date.

Preliminary results from scat analysis indicate that succulent grass and grass-like vegetation is the food taken most frequently and in the greatest amounts over the course of the feeding cycle. This type of food probably contributes most significantly to grizzly energy requirements. These foods are taken primarily during the vegetative growing season. Proximate analysis of grass and grass-like foods and corresponding scat materials indicates that grizzlies are capable of extracting 50% of the protein in the above-ground parts of these foods. Pre- and post-growing season foods are primarily carrion, roots, and corms.

Vegetative plot sampling throughout the feeding cycle indicated a direct relationship between plant succulence, stage of growth, and plant protein levels. Generally the more succulent the plant and the earlier the growth stage, the higher the protein content of above-ground plant parts. Grizzly feeding activity upon grassy vegetation was noted to be most intense in areas where the plants were in their most succulent growth stage.

There is evidence of three distinct and differing grizzly feeding economies in the park. These are (1) mountain economy, (2) valley economy, and (3) lake economy. With the exception of lake economy, the foods consumed are similar. The factor which distinguishes the economies are the bear's apparently different motivations for feeding. There is strong inferential evidence that there are three separate and distinct grizzly population segments which are indigenous to the three respective feeding economies.

Recommendations for future research will be forwarded at a later time under separate cover. The present work should proceed as planned.

# # #

CLIMATOLOGY, GRAND TETON AND YELLOWSTONE NATIONAL PARKS

YELL-N-75

INVESTIGATOR: Richard Dirks
University of Wyoming

SUMMARY OF PROGRESS: A summary of available climatic records was completed 1 July 1974. This summary included descriptions of the climate of various divisions within the parks and a determination of 1941-70 normals for stations in the parks regions. The report also included tabulations of historical data and site descriptions.

Based on this preliminary report, continuing studies were recommended in several areas including: (a) reduction and summarization of raw data records for winds for at least 5-year periods; (b) initiation of wind and temperature measurements along broad slope transects in the parks and in the central Yellowstone Plateau area. To obtain a reasonable climatic record it was recommended that these measurements be continued for approximately three years.

By 1 June 1974, mechanical weather stations were installed near Gardiner, Montana, and Moose, Wyoming. Wind and temperature measurements were also made on the slopes of Rendezvous Mountain near Teton Village, Wyoming, during the summer months of 1974 to supplement data collected there during the winter by the U. S. Forest Service. In October 1974 an additional wind station was installed in the Hayden Valley area of the Yellowstone Plateau.

More than 4 years of fire weather data has been keypunched and a program has been completed for the analysis of fire weather wind data. Data reduction and analysis has also begun for the mechanical weather station records.

In order to improve the data collection at Rendezvous Mountain during May-October 1975 it is recommended that powered anemometers be installed and used with the existing hard line telemetry. Instrumentation costs would be approximately $2000 and telemetry costs approximately $80 per month (Total: $500/season). Beyond this the support level should be approximately the same for the remaining time of the study.

# # #

RESEARCH TO ESTABLISH WHETHER OR NOT MAGMA CHAMBER IS PRESENT UNDER YELLOWSTONE CALDERA AND ITS EXTENT

YELL-N-79

INVESTIGATOR: Robert G. Daniel
Stanford University

SUMMARY OF PROGRESS: Currently reducing and analyzing data obtained in Yellowstone National Park during September 1974 to determine feasibility of using distant earthquakes as tools to investigate structure of high-temperature rock at depths of 1-50 km. Findings to date suggest complex structure in the caldera region, and we expect to expand our program of long-period seismic monitoring to six stations in 1975. The project is proceeding as planned.

# # #

ECOLOGY OF AQUATIC BIRDS ON YELLOWSTONE LAKE

YELL-N-80

INVESTIGATORS: Robert L. Eng and graduate student
Montana State University

SUMMARY OF PROGRESS: In a natural area, piscivorous animals have priority over humans in the use of the fish resource. Thus it is necessary to understand the needs of the animals in order to keep human use to a non-conflicting level. This study was directed toward determining the consumption of cutthroat trout by the 13 major piscivorous species of avifauna on Yellowstone Lake, Yellowstone National Park, Wyoming. Population numbers and distribution were determined by censuses conducted during the summers of 1973 and 1974. Food habit information was obtained by field observations and a literature review. Population numbers were as follows: White Pelicans 400 (1973), 195 (1974); Ospreys 44, 42; Common Mergansers 616, 622; eared grebes 2582, 3071; Barrow's goldeneyes 1470, 1563; buffleheads 100, 93; Bald Eagles 17, 14; California Gulls 2000, 1375; Common Loons 14, 2; Double-crested Cormorants 5, 17; Great Blue Herons 14, 5; Caspian Terns 16, 23; Belted Kingfishers 8, 5. Ten of the species were densest in the arms of the lake, the exceptions being the ospreys with similar densities inside and outside the arms, the grebes on the open water, the kingfishers along the north shore, and the loons which showed no preference for any particular part of the lake. Individual pelicans were found to consume an average of 119 lb cutthroat trout/day, ospreys 0.88 lb/day, mergansers 0.9 lb/day, grebes 0.31 lb/day, golden-eyes 0.005 lb/day, buffleheads 0.01 lb/day, eagles 0.09 lb/day, gulls 0.34 lb/day, loons 1.19 lb/day, cormorants 0.003 lb/day, terns 0.7 lb/day, kingfishers 0.3 lb/day. It was determined that a young pelican utilized 102 lb of cutthroat trout during the rearing period, and a young osprey 61 lb. Total consumption for a 100-day period was 257,967 lb of cutthroat trout in 1973, and 184,635 in 1974. Since mortality in young cutthroat was considered to have no effect on the ultimate size of the adult fish population, the biomass taken by grebes, buffleheads, gulls, loons, terns, and kingfishers was subtracted from the total, leaving a net consumption of 224,993 lb in 1973, and 144,223 lb in 1974.

REPRODUCTIVE BIOLOGY OF TROUT IN A THERMALLY ENRICHED ENVIRONMENT: THE FIREHOLE RIVER OF YELLOWSTONE NATIONAL PARK

YELL-N-81

INVESTIGATOR: Calvin Kaya
Montana State University

SUMMARY OF PROGRESS: This progress report covers only the first 5 months of a proposed 2-year study; therefore, the results which are summarized should be considered very preliminary. Temperature recordings indicate that trout inhabiting the heated-water study area above the Ojo Caliente bridge live at temperatures 10-14°C higher than those inhabiting the cold-water study area below Kepler Cascades. Summer temperatures at Ojo Caliente occasionally reach or exceed published lethal levels for trout, and consistently exceed the 20°C upper limit believed to permit growth. Brown trout from below Kepler show a normal reproductive pattern and spawn sometime in November. However, brown trout at Ojo Caliente appear to have their gonadal maturation inhibited and most appear to thus be functionally sterilized. Rainbow trout at Ojo Caliente undergo gonadal maturation in the fall, and may spawn during the winter. Trout from Ojo Caliente grow slightly faster than those from other upstream stations during the first two or three years, but this growth rate is not rapid in absolute terms. Preliminary observations indicate that trout from Ojo Caliente have very different feeding habits from those below Kepler, and that the former are also considerably more frequently parasitized. These observations will continue for a second year, to follow two consecutive annual cycles. We will also attempt to determine the degree of movement by trout into or out of a given study area, using standard procedures of population census at different times of the year.

# # #

PLANT SUCCESSION AND BIOTIC SUCCESSION IN LODGEPOLE PINE FOREST OF FIRE ORIGIN IN YELLOWSTONE NATIONAL PARK

YELL-N-16

INVESTIGATOR: Dale L. Taylor
Sterling College, Sterling, Kansas

SUMMARY OF PROGRESS: I was inactive in Yellowstone during 1974. My work was concentrated in Grand Teton National Park. One publication was completed: Taylor, D. L. 1974. Forest fires in Yellowstone National Park. *J. For. History* 18(3): 68-77.

The project may be continued at irregular intervals. One research grant proposal has been submitted to the Yellowstone Center for Environmental Studies. If funded, the project will last 2 years.

# # #

IMPACT OF UNCONTROLLED MOUNTAIN PINE BEETLE IN LODGEPOLE PINE
YELL-N-44

INVESTIGATOR: William Klein
U. S. Forest Service

SUMMARY OF PROGRESS: The first phase of this project has been completed and published. The second phase, which includes attack and emerge data from the infested and killed trees, is partially complete, requiring only a publication. The third phase involves trend data from a high elevation plot in Yellowstone, adjacent to Moose Creek Plateau on the Tarohee National Forest. This field work will be completed in 1978.

# # #

MICROBIAL ECOLOGY OF THERMAL ENVIRONMENTS
YELL-N-49

INVESTIGATOR: Thomas Brock
University of Wisconsin

SUMMARY OF PROGRESS: During the past year our work has centered on studies on algal mats in geyser and hot spring effluents in the Lower Geyser Basin, and on bacteria living in hot, acid pools in Norris Geyser Basin, Sylvan Springs, and Mud Volcano area. This work has resulted in the writing of several manuscripts which are now being submitted for publication. Reprints will be sent (as usual) when these papers are published. Over the past 8 years that funded research has been carried out, over 50 research papers and reviews have been written, and copies of these are on file in the Yellowstone library.

We expect to have about eight people working with us during the summer of 1975, carrying out studies in the same areas as outlined above. We anticipate that funding will remain at the current level.

# # #

TROPHICDYNAMICS OF THERMAL SPRING ECOSYSTEMS
YELL-N-53

INVESTIGATOR: Richard Wiegert
University of Georgia

SUMMARY OF PROGRESS: Work on National Science Foundation Grant GB 21255 in Yellowstone Park this past summer involved: (1) Completion of studies of the algal-midge-predator mite community characteristic of the cool area downstream from Solitary Geyser. This work centered on investigation of the effect of predatory mites as a control on the midge and the resultant effect on growth of the blue-green algae on which the midges subsist. (2) Continuation of a wide-range survey of the environmental factors (pH, temperature, flow rate, water depth, and CO_2) on the successional species change and growth rate of filamentous blue-green algae, sampling of over 50 stations at some 14 different locations in the park on a line stretching from West Thumb to midway between Norris and Mammoth. (3) Continued our studies of the ecology of thermal effluent communities developing on experimental "Board" troughs in a small meadow (Seredipity) just off Firehole Lake Drive. This past summer these studies included investigation of algae, flies, spiders, and parasitic wasps preying on the flies.

# # #

CONDITION FOR DEPTH HOAR FORMATION

YELL-N-71

INVESTIGATOR: Charles C. Bradley
Montana State University

SUMMARY OF PROGRESS: The purpose of this project is to obtain field answers to the following questions: (1) What is the ideal thermal regimen for the production of euhedral depth hoar? (2) What is the ideal thermal regimen for the production of a minimum strength zone in depth hoar? (3) What is the relationship between these two conditions?

Depth hoar is notorious for producing the basal weakness in the snowpack which leads to climax avalanche. The Old Faithful field study is part of avalanche research at MSU. The Old Faithful study is being correlated with laboratory investigations into depth hoar formation.

It is well known that depth hoar results from thermal gradient metamorphism and heat flow from the ground up through the snowpack. Old Faithful seems like an ideal study site because of cold winters, thin snowpack and steady flow of geothermal heat.

To date we have discovered: (1) In the snowpack surrounding Old Faithful, there is normally a zone which displays beautifully developed euhedral depth hoar crystals. (2) Often the weakest zone in the pack lies near the top of the depth hoar layer where the crystals are less well-formed. (3) That depth hoar production is usually fairly complete before the end of December and destructive metamorphism is usually apparent by the middle of January.

To obtain measurement, we have three thermister stacks installed about 100 yards south of Old Faithful's vent. They have been giving us a good picture of the thermal gradient from a depth of 25 cm in the ground up through the entire pack. This data will be analyzed for the relationship of heat flow to snow strength and texture after conclusion of the study January 1975.

We appreciate the great help and cooperation we have received from the National Park Service and the local staff at Old Faithful.

# # #

PRELIMINARY INVESTIGATION INTO THE ZOOPLANKTON OF YELLOWSTONE LAKE

YELL-N-82

INVESTIGATOR: John C. Scott
University of Nebraska

SUMMARY OF PROGRESS: A total of 250 collections were taken from various collecting sights on Yellowstone Lake and its lagoons. All samples were taken from 1 June to

1 September 1974. Identification of zooplankton species and their abundance is now underway. At this time, no significant findings have been made. All identification of zooplankton will be completed by March 1974.

# # #

POLLEN AND PLANT MACROFOSSILS FROM LATE PLEISTOCENE SEDIMENTS IN YELLOWSTONE NATIONAL PARK

YELL-N-45

INVESTIGATOR: Richard G. Baker
University of Colorado

SUMMARY OF PROGRESS: Progress on the south and central Yellowstone Plateau is complete. Work will be published next year as a U. S. Geological Survey Professional Paper. Shorter summaries are available in *Science* (1970) and in the *American Quaternary Association Abstracts* (1970). See also Waddington and Wright (1974).

Vegetation in most areas was an alpine tundra or parkland prior to 11,500 years ago. Occasional spruce, fir, and whitebark pine may have been present. Whitebark pine dominated the forests from 11,500 to 9000 years ago, along with lodgepole pine. From 9000 to about 5000 years ago, lodgepole pine was probably more abundant than today. During the last 5000 years, lodgepole pine has still strongly dominated, but spruce and fir have become more abundant, and have probably grown at lower elevations than previously.

RECOMMENDATIONS: No further work is recommended at this time in the central part of the park. I have a proposal pending with the University of Wyoming--Yellowstone Park Association for a pollen analysis of sediments from Blacktail Ponds.

# # #

DEVELOPMENT OF A HABITAT TYPE CLASSIFICATION FOR FORESTED REGIONS IN MONTANA

INVESTIGATOR: Stephen F. Arno
U. S. Forest Service

SUMMARY OF PROGRESS: A detailed forest habitat-type classification has been developed for Montana. The review draft is now being revised (using comments from reviewers) and readied for publication as a station paper.

# # #

STUDY OF ALGAL COMMUNITIES IN YELLOWSTONE RIVER

INVESTIGATOR: Loren L. Bahls
Montana Environmental Quality Council

SUMMARY OF PROGRESS: I analyzed algal and diatom populations from 26 stations along the Yellowstone River from Corwin Springs, Montana, to Cartwright, North Dakota, including the Shields River and Bighorn River tributaries. No samples from Yellowstone National Park yet; I expect to sample the park during the next field season (1975). Striking longitudinal differences noted so far. I expect to continue monthly sampling (conducted by Montana Fish and Game) through winter when possible.

# # #

PARASITES OF UNGULATES, TETON NATIONAL PARK AND ADJACENT AREA

INVESTIGATOR: Robert C. Bergstrom
University of Wyoming

SUMMARY OF PROGRESS: No work could be accomplished in Yellowstone National Park this year. A new ranger had been assigned to the South Entrance station. He told the investigator to check with a District Ranger at Lake and to write a new proposal. In other words, this investigator did not receive much cooperation at YNP as in past years when two different subdistrict rangers at South were very cooperative. Publication of a portion of the lungworm (*Dictyocaulus viviparus*) research will be in the January issue of the *J. Wildl. Dis.* 40-44. Cooperation by Robert Wood and other naturalists and rangers of the Teton National Park has been outstanding on this project from 1968 to date. More work should be accomplished since it was found that chasing the young elk off the National Elk Refuge during May each year helped to reduce the prevalence of infection with the lungworm during 1972, 1973, and 1974.

# # #

STUDIES OF THERMOPHILIC MICROORGANISMS

INVESTIGATOR: Richard W. Castenholz
University of Oregon

SUMMARY OF PROGRESS: The continuing project in 1974 involved almost exclusively the springs in the Mammoth area. The principal purpose was to repeat and comfirm some of the earlier experiments on sulfide utilization by *Spirulina*, a phototrophic blue-green alga characteristic of the sulfide-containing waters below 50°C in this region. Additional experiments stressed the process of sulfide adaptation by *Spirulina*. In essence, the results showed that this organism, when growing in the absence of sulfide, was photosynthetically inhibited by a sudden exposure to sulfide. Consequently it was found that growth in the presence of low sulfide concentrations allowed complete tolerance to high concentrations later. In addition, adapted *Spirulina* was able to make use of sulfide, presumably as the photosynthetic electron donor. ^{14}C-CO_2 incorporation occurred at a normal rate with sulfide present even when the use of H_2O as usual electron donor was completely by the chemical inhibitor, DCMU.

This is part of a larger project which is concerned with the inhibitory effect of sulfide on many different microorganisms of hot springs and the heretofore undescribed utilization of sulfide by a few photosynthetic forms which are tolerant.

# # #

SEDIMENTARY STRUCTURES ASSOCIATED WITH THE PETRIFIED FORESTS OF YELLOWSTONE PARK

INVESTIGATORS: Arthur V. Chadwick)
Earl W. Lathrop) Loma Linda University

SUMMARY OF PROGRESS: Approximately 100 samples collected in stratigraphic section from Amethyst Mountain. Attempts will be made to correlate the palynoflora with leaf and wood floras and with the palynoflora determined for Specimen Ridge by Fisk.

Analysis has begun and at the current rate we expect to have final palynological data in about 9 months. Initial samples yielded spores and pollen in sufficient quantities to warrant optimism.

# # #

SEDIMENTARY STRUCTURES ASSOCIATED WITH THE PETRIFIED FORESTS OF YELLOWSTONE NATIONAL PARK

INVESTIGATOR: Harold G. Coffin
Andrews University

SUMMARY OF PROGRESS: Although rock samples collecting has been concluded, the analysis and interpretation of the data are still progressing. One paper is in press and another is ready to submit. The rock samples have been used for the study of the organic layers associated with the petrified forests. Wood has not been collected. The results indicate that in most cases the matter composing the organic bands has either been deposited submarine or has been totally reworked by water. Copies of reprints will be sent to the Chief Naturalist when they are available.

# # #

PETROLOGICAL STUDIES, YELLOWSTONE PLATEAU VOLCANIC ROCKS

INVESTIGATOR: Robert L. Christiansen
U. S. Geological Survey

SUMMARY OF PROGRESS: Field work for the project, consisting mainly of sampling each of the principal volcanic units of the Yellowstone rhyolite plateau volcanic field, is essentially complete. Analytical work on these samples has only been begun and there has not yet been any opportunity for the interpretation of the data. Separation of the minerals from the volcanic rocks is now underway, and microscopic study and chemical analysis will continue for at least another year before any significant level of interpretation can be attempted.

# # #

THERMAL WATER/SOIL SAMPLES

INVESTIGATOR: Harold F. Foerster
Sam Houston State University

SUMMARY OF PROGRESS: Twenty-four samples were collected from four areas in the park. Samples were collected from Norris Geyser Basin, Nymph Creek (Lake), Firehole Lake Drive (across from Great Fountain Geyser), and from New Highland Terrace (Summit) in the Mammoth Hot Springs area. The samples consist of water, soil, and algal mats.

The planned study project will be carried out in three stages: In state one, the samples will be examined for the presence of spore-forming bacteria. This stage of the study was only recently initiated, and no results have been obtained as yet. If spore-forming bacteria are obtained, pure cultures of these will be prepared for use in subsequent studies. Stage two of the study will be concerned with the temperature and nutritional requirements of each organism for growth and for spore formation. The purpose of this study will be to develop optimum conditions for spore formation with the aim of obtaining high quality spore preparations. The third stage will be a study of the chemical and physiological properties of spores produced by thermophilic bacteria, with emphasis on the requirements for spore germination.

# # #

STUDY OF SEDIMENTOLOGY, GEOCHEMISTRY, AND NATURAL AND MAN-CAUSED HEAVY METAL POLLUTION IN YELLOWSTONE LAKE

INVESTIGATOR: Jonathan H. Goodwin
University of Utah

SUMMARY OF PROGRESS: During the summer of 1974, 10 cores of the bottom sediments of Yellowstone Lake, Yellowstone National Park, were taken. These cores were to supplement those already taken during the summer of 1973 on a previous NSF-sponsored research project, R. B. Smith, principal investigator. The cores range from 2.4 to 6 m in length. To date, 7 cores have been opened, logged for lithologic description, and sampled for paleomagnetic age determinations and chemical, grain-size analyses.

These preliminary tests show that the recent sediments in the deepest parts of the lake are made primarily of diatom frustules. Organic carbon contents range from less than 1% by weight to more than 3%. Age determinations by paleomagnetic methods based on comparison with established secular variation curves suggest average sedimentation rates in Yellowstone Lake of up to 20 cm/100 years. Sulfur and phosphorous contents of the cores appear to vary in the same way as organic carbon, suggesting that diatom productivity increases during times of increased hot spring activity in the Yellowstone Lake drainage basin. Highest average organic carbon contents and sulfur contents were found in the sediments of West Thumb.

New analytical equipment recently installed at the University of Utah will make possible highly detailed, precise analyses of heavy metal contents of very small sediment samples. With this equipment it is expected that the remainder of the project can be completed within 1 year or less. No adjustments in present research plans are required or planned.

# # #

PARASITES

INVESTIGATOR: Richard A. Heckmann
Brigham Young University

SUMMARY OF PROGRESS: Parts of this study have been published in my Ph.D. dissertation (Montana State University) and in the *Progressive Fish Culturist*. The facets I am presently working on are: fine structure of the host cell *Trichophrya* (Ciliate-Protozoa) interface and the taxonomic position of the two species of *Trichophrya* present on 100% of the cutthroat trout and 50% of the longnose suckers in Yellowstone Lake, YNP. I completed the last extensive survey concerning parasites of fishes in Yellowstone Lake which has been published. The fine structure (electron microscope) is highly significant in that I have discovered a new organelle and that the taxonomic position of *Trichophrya* in fishes has been questioned based on my studies. I plan to continue and complete the fine structure work next year.

# # #

COMPARISON WITH ALGAE FROM HYPERSALINE LAGOON IN BAJA

INVESTIGATOR: Robert J. Horodyski
University of California

SUMMARY OF PROGRESS: Organo-sedimentary structures produced by the activity of communities of microorganisms are widespread in Precambrian sedimentary sequences where they have been used for paleoenvironmental and basinal analysis and for biostratigraphic correlation. To fully utilize these structures in Precambrian strata it is necessary to understand the interactions between the environment and the stromatolite-building microbiotas. As these interactions are very difficult to decipher from the fossil record, it is necessary to study modern analogues. However, such environments are rare, being restricted to harsh settings, settings in which grazing metazoa and competing eukaryotic algae are eliminated by high salinity, desiccation, or high temperature. One such environment, a hypersaline lagoon in Baja California, is currently being studied as part of a post-doctoral research project at the University of California, Los Angeles. Of primary interest in this study is to document the interaction of environment and microbiota in controlling the morphology of growing algal structures. Among the cyanophyte mat types found in Baja are tufted structures produced by the thick-sheathed oscillatoracean cyanophyte *Lyngbya aestuarii*. Studies of these structures in Baja have direct application to understanding certain types of Precambrian stromatolites; however, the relative importance of certain environmental and biological factors could not be entirely deduced from examination of such structures growing essentially under one set of environmental conditions. For this reason, cyanophyte mats in hot springs of Yellowstone National Park from which similar tufted-structures were previously reported were studied for a 3-day period in 1974. Observations on these cyanophyte mats has served to clarify the understanding of similar structures in Baja and their application to Precambrian structures.

# # #

HOMING IN CUTTHROAT TROUT

INVESTIGATOR: Lawrence A. Jahn
Western Illinois University

SUMMARY OF PROGRESS: Spawn was taken from the cutthroat trout in breeding condition from Hatchery Creek, 7 June 1973. Fingerlings were used in odor experiments conducted at the Bozeman Fish Cultural Development Center from 20 July to 31 August. Collection of data from these experiments has been collected and analyzed.

In experiments using an unconditioned stimulus of 3.2 ppm whole cutthroat fingerling extract, a response was noted in which the fingerlings moved closer together and deeper in the experimental tank, thus demonstrating a response to the extract. No response was noted when water without the fish extract was introduced. In experiments using a conditioned stimulus of 3.3 ppm tuna extract, fingerlings responded to the odor in either reward or punishment situations. When the olfactory nerves of conditioned fingerlings were cut or when osmic fish were given no odor, no response was obtained. Thus, the olfactory system of fingerling cutthroat trout is functional prior to the fish leaving their homestreams for their lakeward migrations.

Future work should be expanded to include field tests and more sophisticated laboratory testing apparatus than was used in this study. By marking individual fish in groups, statistical evidence could strengthen the conclusions of the present study if repeated.

# # #

STUDY OF BACTERIA IN HOT SPRINGS

INVESTIGATOR: John McGillis
Salt Lake City, Utah

SUMMARY OF PROGRESS: To date microorganisms collected from thermal waters area in Yellowstone have been induced to grow in similar environments to those present in mine dumps. Ability of these organisms to tolerate high metal concentrations and increased oxidation of sulfide minerals is being studied.

# # #

RESEARCH ON ECOLOGY OF THERMAL BASINS

INVESTIGATOR: Richard P. Sheridan
University of Montana

SUMMARY OF PROGRESS: *Cyanidium caldarium* was collected from Nymph Springs and grown in culture medium. These cultures are available to any scientist. The purpose of the investigation is to determine to what extent the carboxylating enzyme Ribulose-1,5-diphosphate carboxylase allows *Cyanidium* to adapt to CO_2. Since this organism must compete in an ecosystem whose acidity precludes the presence of bicarbonate ion and high temperature reduces CO_2, the activity of this enzyme is extremely important for adaptation.

# # #

EFFECT OF REMOVAL OF WASTEWATER TREATMENT PLANT EFFLUENT FROM THE MADISON RIVER, YELLOWSTONE NATIONAL PARK

INVESTIGATORS: Duane A. Klarich) John C. Wright) Montana State University

SUMMARY OF PROGRESS: In past years wastewater from the Madison Junction treatment plant was discharged into the Madison River. In June 1972, effluent was terminated when the National Park Service adopted a percolation-evaporative ponding system for sewage disposal. The purpose of this study was to determine if any alteration had occurred in the Madison River following the elimination of the effluent discharge.

METHODS: Baseline data was readily available from previous studies. Field work to determine current condition of the Madison River was initiated in the late spring of 1973 and terminated in September of the same year. Six sampling stations were established in locations identical to those established in previous studies. Diurnal samples for productivity estimates and chemistry were taken at weekly intervals. Chlorophyll and macrophytic harvest data were also obtained. In addition to the six major stations, four accessory stations were established at which one weekly sample was taken, primarily for the purpose of chemical analysis.

RESULTS AND DISCUSSION: It was predicted that the pre-1972 input of wastewater should have resulted in ammonia, nitrate, and orthophosphate enrichment. This organic enrichment should produce an increase in productivity. Elimination of the discharge should have resulted in a drop in nutrient levels and a corresponding drop in productivity.

The data obtained in the study does not support the above predictions. Mean ammonia concentrations were found to be similar in 1973 and in 1964. Nitrate-nitrogen concentrations were typically less than 0.001 ppm in 1973 as in 1964. Of the critical nutrients, only orthophosphate declined in the predicted manner. However, similar decline occurred in rivers not influenced by the Madison Junction treatment plant indicating that reduced orthophosphate may have resulted from basin-level changes rather than as a direct reduction due to the elimination of the effluent. Productivity as measured by river photosynthesis and chlorophyll accumulation was higher in 1973 than 1964; this is in opposition to the predicted decline.

In both 1973 and in previous baseline studies, downstream parallel declines were observed in river photosynthesis, chlorophyll accumulation, macrophyte standing crop and free CO_2. The study suggests that most of the chlorophyll variation can be accounted for by changes in temperature and free CO_2. The results would indicate that the removal of the wastewater effluent had no pronounced effect on the portion of Madison River under study. It is probable that any influence would have been minor and undetectable relative to the inherent seasonal and yearly variations within the river.

# # #

YOSEMITE NATIONAL PARK

BACKCOUNTRY CARRYING CAPACITIES FOR YOSEMITE NATIONAL PARK

INVESTIGATOR: Jan W. van Wagtendonk
Yosemite National Park

OBJECTIVES: To determine carrying capacities for the backcountry based on physical, ecological, and human factors.

METHODS: This project will synthesize present knowledge, concurrent studies, and the results of original research in deficient areas to develop a conceptual model of the backcountry system.

RESULTS AND DISCUSSION: The various studies being conducted in the park will provide input into the model. These include Robert G. Lee's work on the human component of the system and the project under the direction of John D. Parmater concerning campsite impacts. In addition, small projects are being undertaken to investigate the effects of varying amounts and types of use on trail conditions, littering, and other aspects of impact. The results of all these studies will form input to the model in the form of relationships between use and impact. The acceptable limit of change will have to be identified by management in light of the ramifications of any particular level of use. Once these limits are established, specific capacities can be set for each area of the backcountry.

The capacities will be translated into trailhead quotas by use of a wilderness simulation program developed by the U. S. Forest Service. Inputs to the simulator are actual data such as information concerning the trail system, the user parties, and the routes they take. Trail system data are being complied from maps, previous surveys, and research concerning the effects of trail characteristics on travel behavior. Information about party size, mode of travel, time of trip, and route are present on the Wilderness Permit. Programs are being written to interface the permit data with the simulator.

Outputs from the simulator will be of a statistical nature and will include party encounters and use figures for each trail segment and campsite. Once the actual data are fed in, various management practices can be superimposed on the simulator. The effects of closing trails in stock or of establishing trailhead quotas can be related to encounters and use levels. Through this process, the outputs are examined with respect to the acceptable limits, and then related to trailhead limits. Trailhead quotas would be established through experimentation and would be used to distribute amount and type of use.

PLANS FOR 1975: The human component and campsite and trail impact studies will be completed this year. The primary task will be the integration of all the studies with previous research into the conceptual model. All data necessary for the simulator will be processed and simulation runs initiated. Anticipated publications include reports concerning Wilderness Permit compliance, trail transit times, the interfacing of permits with the simulator, and the application of carrying capacities to management programs.

# # #

GEOLOGIC MAP OF THE TUOLUMNE MEADOWS QUADRANGLE

INVESTIGATORS: Bruce Chappel, Australian National University
Paul C. Bateman)
Allan Busacca) U. S. Geological Survey

SUMMARY OF PROGRESS: The geologic mapping of the Tuolumne Meadows quadrangle was begun in 1972 as a part-time effort on the part of Dallas Peck, R. W. Kistler, and P. C. Bateman, all of the U. S. Geological Survey. Peck is concurrently mapping the Yosemite quadrangle. By the end of 1974, the southern third, a strip across the middle, and about two-thirds of the northwest quarter of the quadrangle were mapped. If all three of us are able to put in uninterrupted field seasons, it may be possible to complete field work in 1975; otherwise, mapping will extend into 1976. During 1974 Bruce Chappell of the Australian National University collaborated in a study of crystallization in the Tuolumne Intrusive Series. Much chemical and microscopic work remains to be done but the field and laboratory data gathered thus far exceed expectations. This subproject will require little field work in 1975, and we hope to complete preparation of a report in late 1975.

STRATIGRAPHY, STRUCTURE, AND REGIONAL CORRELATION OF THE SADDLEBAG LAKE ROOF PENDANT, SIERRA NEVADA, CALIFORNIA

INVESTIGATOR: Charles Brook
California State University and
University of California, Santa Barbara

SUMMARY OF PROGRESS: Project now in manuscript form and being reviewed by editors of the Geological Society of America for future publication.

# # #

AIR QUALITY DETERMINATIONS IN THE YOSEMITE VALLEY AIRSHED

INVESTIGATOR: John J. Carroll
University of California, Davis

SUMMARY OF PROGRESS: During two 3-day periods in the summer of 1973, ground stations and a light twin-engined aircraft were employed to measure the vertical, horizontal, and temperal variations of air temperature, humidity, wind, ozone, and particulate concentrations and size distributions $\geq 0.5\ \mu$ in diameter. These data were taken within and above Yosemite Valley and the lower canyon of the Merced River. Between September 1973 and April 1974 these data were analyzed and additional data on surface winds in the Central Valley and western slope of the Sierra were collected. The final report of these activities is expected to be the Master's thesis of R. L. Baskett who took a career position in Texas in June 1974 and has not finished final draft as yet.

The general results of immediate interest are that the general air quality near the surface of the western slope of the Sierra in summer is primarily governed by transport of pollutants from the West, i.e., the Central Valley. During periods of maximum air pollution in the Central Valley (high pressure aloft, light winds at the surface), the thermally driven upslope flow in the afternoon appears to be very effective in transporting high pollutant concentrations into the Sierra slopes. Therefore, except on still, clear mornings when ground inversions may trap local effluent close to the valley floors, the general air quality over most of the park, most of the time, is a strong function of regional transport from "distant" sources rather than primarily due to local sources.

# # #

EVOLUTION IN NORTH AMERICAN RANIDS

INVESTIGATOR: Susan M. Case
University of California, Berkeley

SUMMARY OF PROGRESS: This study is a continuation and expansion of work conducted last year in which the relationship between *Rana boylei* and *R. muscosa* was investigated. One researcher has hypothesized that *R. muscosa* may represent several cryptic species, each restricted to a single drainage system in the high elevations of the Sierra Nevada, while others feel *R. muscosa* is a single species. Cytological and biochemical approaches to this question are being used.

Measures of genetic similarity (S) and genetic distance (D) were calculated from electrophoretic data on 18 loci. This indicated that *R. muscosa* populations from five drainage systems (including 20 animals from the Tuolumne river drainage in Yosemite National Park) are very closely related. The magnitude of the values observed do not support the hypothesis of several cryptic species being included in *R. musocsa.*

Antibodies to purified albumin of both species were prepared and microcomplement fixation experiments are being conducted to compare the albumins. I also hope to include *R. cascadae, R. aurora,* and *R. pretiosa* in this study since (very) preliminary electrophoretic data suggests these may be more closely related to *R. boylei* and *R. muscosa* than is *R. tarahumarae*, a Mexican member of the *Rana boylei* species group.

# # #

THE STATUS OF THE SPOTTED OWL IN CALIFORNIA

INVESTIGATOR: Gordon I. Gould, Jr.
U. S. Forest Service, California Department of Gish and Game

SUMMARY OF PROGRESS: Surveys to locate spotted owls were conducted throughout the wooded, montane areas of California from 18 July to 28 September 1973 and 4 March to 12 July 1974. Owls were located using recorded and vocal calls, calling either continuously or at invervals along roads and trails through logged and unlogged areas.

Literature and museum records established the past distribution of spotted owls in California. Present distribution was determined in 33 counties extending along the north coast from Del Norte County to Marin County, along the south coast from Monterey County to San Diego County, and along the western slope of the Sierra Nevada Mountains from Kern County to Plumas County. A minimum of 263 spotted owls, representing 192 pairs, were located. Five major population concentrations were noted. The lowest relative abundance of spotted owls occurred in the northern part of the south coast area and the highest in the Douglas fir belt in the north coast area and in the mixed conifer belt of the southern Sierra Nevada Mountains. The spacing of adjoining territories and minimum territory size were estimated. A reduction of 27% in the number of occupied, historical sites may indicate a downward trend in the population size of spotted owls in California.

# # #

ASYMETRIC GLACIER FLOW NEAR THE CREST OF THE SIERRA NEVADA, CALIFORNIA

INVESTIGATORS: Conrad McCarthy)
Ronald Shreve) University of California, Los Angeles

SUMMARY OF PROGRESS: I have completed the bulk of the field work for the project although a recheck trip may be necessary. I am in the process of writing up a report of the field portion of the project and attempting the computer modeling of the flow divide. This modeling may not be possible because the areas mapped may require consideration in three dimensions due to irregular topography; the program I have considers only two dimensions.

Some preliminary comments on the areas mapped: Mono and Parker passes--It appears that the flow divide in Parker Pass was fairly coincident with the topographic divide but in flowing toward Tuolumne Meadows the ice breached the ridge separating Mono and Parker passes. In Mono Pass, ice coming over the ridge from Parker Pass and ice flowing off Mount Gibbs diverged with the flow divide located about 1000 ft west of the present topographic divide. Gaylor Lakes and Tioga Pass area--Here it appears ice flowed out of Granite Lakes Cirque and was divided by Gaylor Peak. The flow divide appears to be located about 1500 ft west of the Sierra Crest. In Tioga Pass there are very few bedrock exposures so the flow direction is uncertain. Further work may be necessary here.

The comments above are only indications of the trend of my thinking at this point. More definite conclusions and maps will be forthcoming by July in the final report.

# # #

THE POLLINATION ECOLOGY OF THE SIERRA NEVADA MOUNTAINS OF CALIFORNIA

INVESTIGATOR:	Lazarus W. Macior University of Akron
SUMMARY OF PROGRESS:	Field work has been completed as of 1 September 1974; laboratory procedures and data reduction should be completed by June 1975.
SIGNIFICANT FINDINGS:	A final report will be submitted to the University of Akron Faculty Committee on Research in June 1975. Copies will be available upon application to the Coordinator of Research.

Research data collected in the field include (1) blooming phenology of 17 plant species, (2) self-pollination potentials of 12 plant species at 16 sites, (3) modes of vegetative reproduction of 12 plant species, (4) reflectance profiles of corollas of 11 plant species for 10 visible and one ultraviolet wavelength, (5) collection of approximately 4000 pollinating insects on plants, cinematographic records of pollinator behavior on *Pedicularis* species, (6) identifications (in progress) of pollens in foraging insect's corbicular loads of pollen, (7) data on locations of specific plant populations studied.

RECOMMENDATIONS: The research could be expanded profitably to include other plant species and their pollinators and thus provide a source of information on the modes and success of sexual reproduction of angiosperms in montane-alpine regions. A study of this type was conducted on the present project under National Science Foundation auspices and published (Macior, L. W. 1974. *Pollination ecology of the Front Range of the Colorado Rocky Mountains*. Melanderia(Wash. State Ent. Soc. Monograph series) vol. 15. 59 p.). A similar study was completed in the St. Elias Mountains (Yukon Territory) under National Science Foundation auspices, and a manuscript for publication is now in preparation.

# # #

PIUTE CUTTHROAT TROUT

INVESTIGATOR: Terry Mills
State of California, Department of Fish and Game

SUMMARY OF PROGRESS: The Piute cutthroat trout in Delaney Creek are to serve as a source of Piutes for introduction into barren Sierra streams. Unfortunately, the presence of eastern brook trout in the creek has severely affected the Piutes by the competition they provide. A 2-day survey of Delaney Creek during October 1974, found that the 1973 removal of eastern brooks had not made any significant difference in the Piute population. It is estimated that there are 60 Piutes per mile of Delaney Creek. During this year's survey 570 eastern brook trout were removed. The following is a brief summary of the survey:

From Skeleton Lake downstream to 0.5 mile above meadow - No fish sighted.
From 0.5 mile above meadow to fork - CT-P - 54; EB - 379.
From forks downstream 1 mile - CT-P - 53; EB - 191.

Total CT-P - 107; EB - 570

1975 plans for the Piutes include electrofishing to remove eastern brook trout and competition of spotting counts of all Piute cutthroat trout. Several representative specimens will be collected.

# # #

BLACK BEAR ECOLOGY

INVESTIGATORS: Marshall White) University of California, Berkeley
David Graber)

SUMMARY OF PROGRESS: The first summer of work (full-time) and fall (part-time) have been completed. A summary of the progress to date is being prepared and will be submitted during January 1975. The initial phase of this study emphasized capture, marking, and release of bears in Yosemite Valley. Additional activities included observation of bears, collection of bear scat, habitat evaluation, and assistance with the ongoing park bear management program. Thirty-three bears have been handled to date, seventeen males and sixteen females.

We recommend continuing this study as proposed. We are preparing to initiate the 1975 field studies in the spring as the bears emerge from hibernation.

# # #

ATTITUDES OF YOSEMITE NATIONAL PARK SERVICE EMPLOYEES TOWARD THEIR WORK AND INTRODUCTION OF A QUEUING DEVICE AT YOSEMITE VALLEY BUS STOP

INVESTIGATOR: Allan W. Wicker
Claremont Graduate School, Claremont, California

SUMMARY OF PROGRESS: In the first project, we examined how different levels of job demands affect the work attitudes and experiences of selected categories of

National Park Service employees: patrolling rangers, campground kiosk attendants, entrance station attendants, interpreters. (Variations in job demands may result from such events as changes in work assigments or changes in number and type of visitor contacts.) The employees were asked about their work experiences on three different kinds of days: (1) when job demands were lighter than average, (2) when job demands were about average, and (3) when job demands were greater than average. Questions dealt with such job-related experiences as how personally involved the employee was in what he did on a particular day, how well he felt he was serving park visitors, the extent to which he felt under pressure in carrying out his duties, and who or what he felt was responsible for the pressure. Other questions dealt with general job characteristics, such as how much freedom the employee's job allowed him to plan his own work activities, and with perceptions of visitors, such as what percentage of park visitors was pleasant to deal with.

In the second project, we attempted to assess the effectiveness of a queuing device designed to channel passengers onto the free valley shuttlebuses more efficiently and more equitably. During a 3-week baseline period, we recorded, at two of the most heavily-used valley bus stops, such information as number of passengers stranded (unable to board a bus because it was full), and frequency of inappropriate behavior, such as shoving, shouting, running, and boarding or exiting the bus through windows. A queuing device was then installed at one of the bus stops, and the same kinds of data collected on both stops for another 3-week period.

Data on both projects were collected during the summer of 1974 and are now being analyzed.

# # #

PRECIPITATION DISTRIBUTION IN THE CENTRAL SIERRA NEVADA

INVESTIGATOR: D. L. Morgan
California State University, Fresno

SUMMARY OF PROGRESS: Data gathered by the Atmosphere Water Resources Research group during the past 5 years are being sought for reduction and publication. Precipitation data gathered during the last water year (1973-74) have been obtained and logged. The missle gages at Tenaga Lake, Tuolumne Meadows, Tioga Pass, and Saddle Bag Lake have been prepared for the coming season.

Precipitation totals for summer 1973 to summer 1974 were as follows:

Tenaga Lake	--	45.34 inches
Tuolumne Meadows	--	42.85 "
Tioga Pass	--	42.74 "

# # #

THE EFFECT OF A NATURAL ENVIRONMENT ON A CHILD WITH SPECIFIC LEARNING DISABILITIES

INVESTIGATOR: Henry W. Munroe
New Hampshire College and University Council

SUMMARY OF PROGRESS: The basic test data was run at Yosemite the summer of 1973 with the 7-year-old subject under observation and performing the assigned tasks without benefit of controlled drugs. The major disability is the inability to assimilate spatial concepts plus advanced perseveration. The basic journal entries and base-line data were established without drug use. The second portion of the project was to have been completed during the summer of 1974. During the second portion, Ritalin--in the amount of 5 mg per day--would be administered. Unfortunately, the energy crisis and unforeseen demands necessitated the project to be delayed. In order to assure continuity, the wexler has been administered under control conditions for comparison. The second portion hopefully can be carried out during the summer of 1975.

# # #

BIOLOGICAL EVALUATION OF *FOMES ANNOSUS* IN YOSEMITE VALLEY

INVESTIGATOR: J. R. Parmeter, Jr.
University of California, Berkeley and Region 5, U. S. Forest Service

SUMMARY OF PROGRESS: The project is rather indeterminant, since work should continue until results provide an adequate basis for predicting the future of pine stands in the valley. To date, over 100 *F. annosus* centers in developed sites have been mapped and the progress of the centers has been monitored each year since 1971. New centers are included as discovered. Since mapping in 1971, some additional centers have been confirmed and another 20 or so I suspected. Data are being collected on annual mortality, rate of spread, rate of occurrence of new centers, length of time necessary to kill trees, and root condition (hazard) associated with various crown symptoms. Since a complete report is now in preparation, I won't include details here. I will mention that we want to: (1) continue annual observations for at least the next 5 years and (2) initiate studies on correlation of crown symptoms with root deterioration by pulling trees.

# # #

BIOLOGICAL FRACTIONATION OF METALS IN NATURAL SYSTEMS

INVESTIGATORS: Clair C. Patterson)
Todd Hinkley) California Institute of Technology, Pasadena
Robert Elias)

SUMMARY OF PROGRESS: Analysis of lead and other metals in dust, snow, plants, and animals from a canyon in Yosemite National Park has led to a number of new findings regarding the probable extent and effect of lead pollution in the total United States population which show that prevailing views regarding the health hazards associated with the use of leaded automotive fuels are grossly wrong and should be drastically revised.

The total inputs and outputs of these metals via dusts, precipitation and stream runoff were measured together with their distributions in rock, soil moisture, plants, and animals within the ecosystem.

Six of the metals (K, Rb, Cs, Ca, Sr, Ba) conformed to behavior expected in a natural geochemical weathering cycle, that is, the amounts leached out by streams averaged about 7 times greater than the amounts added to the ecosystem by dusts and precipitation. But lead did not exhibit this natural behavior in the ecosystem; instead, 65 times more lead was added to the ecosystem from the air than was removed by streams. This unnatural excess was shown to originate from industrial sources. Two different methods of evaluation indicated that from 20 to 80% of the lead in the soil humus of the mountain valley ecosystem probably came from industrial lead aerosols added during the past 80 years. The amount of industrial lead added to the ecosystem each year was about 4 times larger than the total amount of lead contained in all plants and animals living there, and was about 40 times larger than the total amount of lead passing along food chains within the ecosystem each year. Five-sixths of the lead in mountain meadow sedge and in mountain meadow voles eating the sedge came from industrial lead aerosols.

# # #

MERCED PEAK

INVESTIGATOR: Dallas L. Peck
U. S. Geological Survey

SUMMARY OF PROGRESS: The Merced Peak project is aimed at a geologic analysis of the Merced Peak, Yosemite, and Tuolumne Meadows quadrangles, (the last in cooperation with P. C. Bateman and R. W. Kistler, USGS, Menlo Park), Sierra Nevada, California. Emaphais is on the composition, structure, relative age, and relationships of the granitic and metamorphic rocks. Long-range plans include preparation of colored geologic quadrangle maps and topical studies of the several granitic series.

The geology of the Merced Peak quadrangle has been mapped and a preliminary map (MF-281) published in 1964. Mapping of about two-thirds of the Yosemite quadrangle and most of the southern third of the Tuolumne Meadows quadrangle was completed during the summer of 1974. The Yosemite quadrangle is largely underlain by granitoid rocks of five major plutonic series, the contacts of which extend northwesterly across the area. From west to east these are as follows: (1) Granodiorite and tonalite of the Gateway (and granite of Arch Rock), which intrude siliceous metasedimentary rocks of the Calaveras Formation on the west; (2) the younger El Capitan Granite (and granodiorite), the core of which is intruded by several bodies of the related Taft Granite; (3) a younger, large, zoned pluton centered at Ostrander Lake that has margins of granodiorite and tonalite (Illilouette Creek body) and a granitic core; (4) the southern tip of a younger zoned body containing plagioclase-porphyry granodiorite on the margin (granodiorite of Yosemite Creek of Rose) and Sentinel Granodiorite, (*sensu strictu*) in the core; and (5) marginal phases of the Tuolumne Intrusive Series including tonalite and granodiorite and younger Half Dome Quartz Monzonite. Granodiorite and tonalite of the last three units were all assigned to Sentinal Granodiorite by Calkins (1930) and others. Areas in the quadrangle still to be studied are the canyon of the South Fork of the Merced River and areas to the south and west.

# # #

BENTHIC ANIMALS IN TUOLUMNE MEADOWS PONDS

INVESTIGATOR: Carolyn J. Tiernan

SUMMARY OF PROGRESS: Although this study of benthic animals is essentially complete, it opens the way for more extensive investigation. The report shows, for the first time, exactly what invertebrate animals live in Tuolumne Meadow's ponds and what environmental factors may affect the ecology of their populations. Animals were collected, counted, and identified, and the resulting population statistics were mathematically analyzed.

Since so little is known about these smaller park inhabitants, it probably would be worthwhile to at least make a more extensive inventory of what species exist and to study population cycles through several seasons. This undertaking, while time-consuming, would be valuable since these animals are at the bottom of many food chains and are directly affected by water quality.

# # #

SUMMER BEHAVIOR OF THE CLARK'S NUTCRACKER (*NUCIFRAGA COLUMBIANA*) IN THE SIERRA NEVADA

INVESTIGATOR: Diana Francine Tomback
University of California, Santa Barbara

SUMMARY OF PROGRESS: To date, general observations have been collected on Clark's Nutcrackers in regard to seasonal changes in feeding strategy, fall storage of pine seed, and adult and juvenile interactions. Tapes have been made of nutcracker vocalizations at different times of the year, and 16-mm high-speed films have been taken of nutcrackers opening whitebark pine cones for analysis of motor patterns involved. The major area of concentration has been the pre- and post-roosting behavior of the nutcracker in relation to thermoregulation--i.e., whether the birds appear to take advantage of direct sunlight for warming purposes during early morning hours and prior to sunset.

SIGNIFICANT FINDINGS: Instrumentation on Gaylor Ridge and near the trail to Mount Dana, at 10,480-ft elevation in both areas, has monitored temperature and light variations throughout the summer. Data have been correlated with evening and morning movements of the nutcrackers, as well as a few other passerine species, and indicate that the birds may be responding to sunlight availability. Changes in these movements may be caused by: (1) availability of much food, i.e., when the pine cones are ripe, and (2) light direction shift and decrease in light intensity near the time of the autumnal equinox. Extra food may be used for temperature maintenance during the coldest time of the day rather than sunbathing.

FUTURE PLANS: Laboratory experiments will be conducted on captive specimens of the nutcracker this spring (taken from the Mammoth Lakes area) at the University of California, Santa Barbara. The experiments will verify whether the nutcracker morning and evening movements are indeed in relation to thermoregulatory behavior, or are phototactic or social responses. One more summer is necessary to gather more observations on this phenomenon, if experiment results support the hypothesis.

# # #

STUDIES OF THE ROLE OF WARMBLOODED VERTEBRATES IN HELPING TO REDUCE AMOUNTS OF ORGANIC DEBRIS AROUND BACKCOUNTRY CAMPSITES

INVESTIGATOR: Henry G. Weston, Jr.
San Jose State University

SUMMARY OF PROGRESS: Field research was continued in 1974. Studies have now covered parts of Yosemite National Park, John Muir and Hoover wilderness areas, Emigrant Basin and Desolation Valley primitive areas, Investigations were continued in 1974 centering in the Tuolumne Meadows area of Yosemite as well as Emigrant Basin and Desolation Valley. A smorgasbord approach of placing a variety of foods out for animal use was followed in 1974 as during previous summers. Efforts were concentrated on birds (juncos, nutcrackers, white-crowned sparrows, jays, blackbirds, robins, cowbirds) and mammals (chipmunks, groundsquirrels, marmots, and bears). To date, 77 distinct, different food items have been placed out and taken by birds and/or mammals. Some animals, particularly mammals do play a significant role in removing organic garbage. This role is most significant along the main trails, less so along lateral trails.

# # #

ECOLOGICAL REQUIREMENTS OF MULE DEER

YOSE-N-1a

INVESTIGATORS:
A. Sansum)
R. Riegelhuth) Yosemite National Park
D. Harms)

SUMMARY OF PROGRESS: Yosemite 1974 deer management investigations included: (1) pellet group readings on 23 permanent transects, (2) establishment of permanent photo reference points on range transects in four key areas, and (3) winter and spring deer herd composition counts.

Deer use per acre on high summer ranges indicated 18 to 26 days use, showing slight variation from 1973, despite non-measurement of extremes. The spring fawn-doe ratio of 47:100 represents an over-winter survival rate of 87%. Fawn production reaching the winter range (December 1974) increased from 54/100 does (1973) to 56/100 does. Deer were observed to be in excellent condition with an unusually large number of spike yearlings.

RECOMMENDATIONS: No post-season or special hunts are recommended in view of: (1) a static deer population as indicated by herd composition counts and deer use data; (2) improved range conditions as indicated by the 1973 and 1972 vegetative range surveys.

# # #

MERCED RIVER FISHERY INVESTIGATION

INVESTIGATOR:
Phil Bartholomew
California Department of Fish and Game

SUMMARY OF PROGRESS: This year an investigation was begun to determine if the Merced River below Yosemite Park would be suitable for inclusion into California's wild trout stream program. By policy, wild trout streams are not stocked with catchable-size trout. About 45,000 catchable-size rainbow trout are stocked annually from El Portal at the park boundary 8 miles downstream to the confluence of the Merced and South Fork Merced Rivers. A comparison is being made between the river in the park (unstocked) and downstream (intensively stocked). This year a creel census was conducted, a face plate fishery survey was made, and trout were captured, tagged with $5 reward tags and returned to the water, and scales were removed from trout for age and growth analyses.

SIGNIFICANT FINDINGS: Two people floated for about 35 miles between Sentinel and El Capitan bridges and tallied as many fish as possible en route. Of the 1,072 fish counted, 678 (63%), 12.6 (12%), and 268 (25%) were brown trout, rainbow trout, and suckers, respectively. Counts in 3 pools from the Pohono Bridge area to Wildcat falls provided similar ratios. Twelve trout taken from 1 mile above Pohono Bridge to 1 mile above El Portal were tagged and released. None of the tags have been returned to date. In the stocked section downstream, 100 trout were tagged with reward tags and 56 have been returned to date. These data suggest that either the angling pressure is extremely light or there is an extremely large trout population in the stream. Both are probably true.

An effective creel census program was not successful because most of the river is too far from the roads to visit within a reasonable length of time and park visitors continually asked questions unrelated to the project.

Scales taken from trout for age and growth purposes have not yet been analyzed.

FUTURE PLANS: Creel census--an effective census can be made by floating or canoeing the river. We will attempt this from about Happy Isle to the lower limits of safe navigation. Tagged fish--this year, all our tagged trout we captured at the lower end of the valley. I would like to tag 50 with $5 reward tags in 1975 if funds are available. Age and growth--we obtained very few scale samples (less than a dozen) this year. I would like to collect scales from about 50 trout in 1975.

Generally, our work this season was of a preliminary nature and is too early to draw conclusions.

# # #

THE MANAGEMENT OF HUMAN COMPONENTS IN THE YOSEMITE NATIONAL PARK ECOSYSTEM

INVESTIGATOR: Robert G. Lee
University of California, Berkeley

SUMMARY OF PROGRESS: The backcountry and interpretive program components were studied in order to: (1) discover and anlayze behavioral processes related to social carrying capacities, and (2) utilize these data in evaluating management alternatives for these components by linking management inputs with behavioral and attitudinal variables.

Visitor perceptions and behavioral adaptations to crowding or resource degradation were studied separately in Trail Corridors and Camps. Both behavioral and attitudinal measures were made in each of these subcomponents, permitting the researchers to compare people's verbal responses to their actual behavior. Attitudes were also compared with the actual conditions of the social and physical environment.

Nature walks with 30 different titles were enumerated, and a total of 74 walks were observed. A de facto census of all individuals and groups was made at the beginning of each walk, and individuals were randomly selected for 20 minute observation periods. These individuals were contacted after the walk and asked to fill out a questionnaire. A total of 233 individuals were observed on all walks, and 190 of these individuals returned usable questionnaires.

# # #

SYSTEMATIC STUDIES OF THE NEARCTIC SPECIES OF GENUS *NEBRIA* LATREILLE (COLEOPTERA; CARABIDAE; NEBRIINI)

YOSE-N-2217

INVESTIGATOR: David Henry Kavanaugh
California Academy of Sciences

SUMMARY OF PROGRESS: My systematic study of *Nebria* species is entering its final year. Geographical and ecological distributions of Nearctic species are fairly well-defined at present, including the species living in Yosemite National Park. Analysis of evolutionary and zoogeographic relationships among the species will begin shortly.

SIGNIFICANT FINDINGS: Field work in the High Sierra during the past year, including extensive night collecting (these insects are nocturnally active), has shown that the high altitude species are active on snowfields and glaciers at night, where they feed on the stranded invertebrates that land on these cold areas during the day and remain trapped there. It seems most probable that this influx of food from lower elevations (wind-blown predominantly) forms the stable nurtient base for these populations. Survey of the habitat indicates that possible resident food sources are minimal, and that high populations of the beetles studied probably depend on nutrient input from other habitats.

FUTURE PLANS: Future plans for research include a faunal analysis of the Sierran region ground beetles in general, concentrating especially on the high altitude areas.

# # #

BLACK BEAR POPULATION OF THE YOSEMITE VALLEY AND HUMAN-RELATED BEHAVIOR

INVESTIGATORS: John R. Parmeter)
Ellen Kaye) University of California, Berkeley

SUMMARY OF PROGRESS: A National Science Foundation grant entitled *Black Bear Population of the Yosemite Valley and Human-Related Bear Behavior* was conducted in Yosemite National Park from 30 June to 8 September 1974. The three project objectives were: to estimate the size and characteristics of the bear population in Yosemite Valley; to examine bear feeding habits, particularly the proportions of natural and non-natural foods; and to determine if new bear behavior patterns have emerged in response to human induced changes of the bear environment. The black bear population of Yosemite Valley was estimated both by the Lincoln-Index Method and by absolute count over a period of intensive observation (1 July to 28 July 1974). The estimated bear population was 32 both by direct count and by averaging the results of the first two Lincoln Indexes.

The bear population of the valley was transient, remaining in the area for a period of time then moving out. From observation records during the project director's spring internship in Yosemite, it could be seen that the bear population existing in the valley during July was different from the spring population. Similarly, at the conclusion of the project's intensive observation period, there was another influx of bears and an exodus of some previously identified bears.

Bear populations existing in the valley, and in the vicinities of Tuolumne Meadows and White Wolf Campgrounds, are larger than naturally existing populations would be. Natural food sources in the valley are not sufficient to sustain 32 bears, and the bears rely on non-natural food sources for added sustenance. An analysis of valley scats indicated garbage present in 38.3% of those collected, while in Tuolumne 75% of the scats contained garbage. The valley contains better bear habitat than do the higher elevations such as Tuolumne Meadows. Natural food items in the valley included acorns (*Quercus* spp.), berries (*Rubus* spp. and *Ribes* spp.), dogwood (*Cornus* spp.), and apples (*Malus* spp.) which are not naturally occurring but remain from previous orchards. At higher elevations, most of these food items, with the exception of berries, are lacking.

Observations of valley dumpsters indicated that dumpsters were used quite extensively by some bears and to a lesser degree by others. During one 2-week period, 5 of the 23 identified valley bears were observed rummaging through one particular dumpster nearly every night. In addition to dumpsters, bears obtain non-natural food through "bum behavior" such as stealing food from picnic tables and breaking into cars.

# # #

LODGEPOLE NEEDLE MINER
YOSE-N-30

INVESTIGATOR: Thomas W. Koerber
Pacific Southwest Forest and Range Experiment Station

SUMMARY OF PROGRESS: Lodgepole needle miner population samples obtained during the summer of 1974 show that the needle miner populations have declined from the levels present at the comparable stage in the insect's life cycle in 1972. However, they remain higher than they were in the comparable stage of development in 1970. The present population levels reflect the effect of heavy needle miner mortality caused by winter temperatures which reached minus 28°F in December 1972. The reproduction rate of the moths has not yet offset the mortality suffered at that time.

It is significant that the "refuge" areas which had earlier been identified as supporting higher needle miner populations in the face of unfavorable summer weather conditions proved, in general to be the least favorable for survival when low winter temperatures were the mortality factor.

As recommended in my last investigator's report, the level of effort devoted to this project was reduced. Yosemite National Park presents a unique opportunity to study a forest defoliator unhindered of pest control or timber salvage operations. I plan to continue to monitor the needle miner population at the present reduced level of effort with the objective of improving our understanding of the basic ecological processes involved. I hope the information obtained will continue to be of value to the interpretive program.

# # #

CARRYING CAPACITY RESEARCH

INVESTIGATORS:
John R. Parmeter)
Daniel O. Holmes)
Joseph E. Holmes) University of California, Berkeley
Luci Malin)
Anne Z. Parker)

SUMMARY OF PROGRESS: Studies were conducted near 9600 ft at Nelson and Matthes lakes. Initially, base-line data was gathered: lake size and physical characteristics of the water were measured; human use areas (especially camp areas) were described in terms of topography, vegetation and artifacts, (e.g., firerings); soils were characterized and typed; plants and plant communities were identified; and a weather station was established. A reference grid with datum points every 10 m was surveyed along the shores and through the camp areas of both lakes.

Major studies included: (1) observation of the numbers, locations, and behavior of the wilderness visitors, (2) experimentation with various techniques utilizing lightweight field equipment for measuring human use and environmental characteristics, and (3) measurement of the physical impact of the visitors upon the water quality, soils, microclimate, and vegetation. These studies specifically measured: (1) water alkalinity, pH, turbidity, dissolved oxygen, phosphate, nitrate nitrogen, coliform, and plankton, all possibly affected by or related directly or indirectly to human use; (2) variations in temperature and relative humidity on and off trails were noted; (3) soil particle size, bulk density, compaction, type, color, nitrate nitrogen, nitrite nitrogen, ammonia nitrogen, magnesium, manganese, potassium, calcium, aluminum, iron, phosphorus, and pH were intensively measured in areas of different use levels and in different plant communities; (4) plant color, defoliation, vigor, composition, and distribution were observed as affected by trampling, urinating, and other activities. Most of the data collected is still being analyzed. However, some preliminary results and a plan for further study are ready.

SIGNIFICANT FINDINGS: (1) Water quality: Nelson and Matthes lakes and nearby streams have shown up to 220 coliform bacteria (of unknown origin) per 100 ml of water; this indicates far less purity than treated drinking water as specified by the American Public Health Association although it is within the Federal Water Pollution Control Administration's allowable limits for primary contact recreation. (2) Microclimate: the trail environment differs from adjacent plant communities in several ways: trails and plants on trails have higher temperatures and lower relative humidities; plants on incipient trails have higher leaf temperatures. In addition, some plant species that have been trampled have leaf temperatures in excess of ground surface temperatures. (3) Soils: soils in this subalpine area are poorly developed, shallow, and very acid, (pH from 3.9 to 5.3). All nutrients and trace nutrients measured are at low or very low levels except iron and aluminum. Vegetation cover is probably the most important factor in determining the vulnerability of a soil to compaction. (4) Vegetation: on most low-growing, subalpine plants, the application or urine in the quantities adults usually void, (approximately 200 ml on 100 to 200 cm^2 of ground), proves extremely damaging if not fatal to the plants contacted. Plant species that favor dry habitats are generally less vulnerable to urine than those in wetter environments. Some plant species dying from urine application develop colors and color change patterns distinctly different from those killed by other means. The relative trampling tolerance of the 22 species we studied range from 1 to 20. Within a small area, varying microclimate due to overhead vegetation, topography or prolonged snow cover can yield widely varying growing, budding, blooming, and seed setting periods for the same species. Year to year seasonal variations often make annual comparisons difficult and inconclusive.

An additional summer of field work followed by several months of report preparation should provide adequate information for devising an ecological carrying capacity formula for Yosemite's lodgepole-subalpine ecosystem. This would require $7000 additional support. The work would include follow-up on the urine and trampling studies, observation of visitor behavior, a multiple lake and stream fecal and total coliform bacterial monitoring program, development of rapid survey techniques for inventorying impact and environmental characteristics of visitor use areas, and preparation of and experimentation with an impact monitoring methodology.

# # #

BIOSYSTEMATICS STUDIES IN THE EASTERN SPECIES OF *HEUCHERA* (SAXIFRAGACEAE)

INVESTIGATOR: Elizabeth Fortson Wells
University of North Carolina, Chapel Hill

SUMMARY OF PROGRESS: The breeding system of seven eastern species of *Heuchera* has been investigated. Almost all combinations are completely fertile, except when *H. villosa* and *H. parviflora* are the pollen parents. Crosses between eastern species and selected western species of *Heuchera* will be attempted this year. Flavonoid of eastern and western species are being investigated, using plants transplanted from the wild to a greenhouse in Piedmont, North Carolina. Flower ontogeny, inflorescence branching, leaf anatomy, and gross morphology are being compared in an attempt to elucidate the relationships between the species.

Artificial hybrids from all combinations of eastern species are germinating and growing with varying success. The entire project should be completed by May 1976. Work comparing the genus *Heuchera* with other closely related herbaceous genera is planned for the future.

# # #

MONOGRAPHIC (BIOSYSTEMATIC) RESEARCH IN THE GENUS *LUPINUS*

INVESTIGATOR: David B. Dunn) University of Missou
Patricia Vaughn)
Melvin Conrad, Northeast Missouri State University

SUMMARY OF PROGRESS: I have been working in the genus *Lupinus* since my senior project at UCLA in 1939, under Carl Epling, and have the lupines of Canada and Alaska completed as well as the lupines of the Rocky Mountains of the United States. Those of the southwestern United States and adjacent Mexico are near completion. The west coast studies represent an effort to study the remaining complexes of *Lupinus* that are endemic to that region. I graduated from Yosemite Field School in 1940. There are three current monographic research projects on the west coast lupines and three in Mexico and Central America, with different graduates working in the two areas. Two of the west coast monographs will be finished by the summer of 1975, copies of the theses will be sent to the Yosemite Museum library. (1) The *Lupinus latifolius* complex, is a closely related group extending from Washington to Baja, and the MA thesis is progressing well. The dissections of flowers, morphological studies and about 100 thin-layer chromatographic analyses on the alkaloids of lupines aid in identifying the closeness of the geographic races or the extent of difference. Colonies in the central Sierra Nevada show greater affinity with those of southern California than with the Northern Coast Ranges. (2) The study of the *Lupinus albicaulis-L. andersonii* complex (Ph.D.) is farther along and much more complicated. It includes 90 published epithets, of which we were successful in locating the type localities and living specimens of well over half during the 1973 field work. The complex extends from Washington to Baja. Morphological studies have been supplemented by flower dissections and chromatographic studies of both the flavinoids and alkaloids. Some of the taxa shown as synonyms in Munz's Flora of California in Lupinus, (which I helped assemble) have turned out to be very distinct, while others show different affinities than we had been aware of. (3) The *Lupinus oreganus-L. nevadensis* complex study is in its infancy. We made extensive field studies and collections during the summer of 1973 in preparation for the work on the complex but the student who had planned to work on the group has not finished his prior project so a new student has been assigned to the project as of the fall of 1974. There are approximately 35 epithets applied to material in the complex. Most of them are in Washington and Oregon but *L. breweri*, *L. duranii*, *L. nevadensis* and several others extend into or along the Sierras. When these studies are completed the *L. densiflorus* complex will be the only one in the United States and Canada that either my student or I have not studied. This last group is currently being studied by a doctoral candidate at Riverside, California.

# # #

A POST GLACIAL POLLEN RECORD FROM A SUBALPINE VALLEY IN YOSEMITE NATIONAL PARK (POLLY DOME LAKES AREA)

INVESTIGATOR: John R. Batch
San Francisco State University

SUMMARY OF PROGRESS: Pollen analysis is approximately 80% complete. Sediment size analysis remains to be done. Of significance, a radiocarbon date of 9150 - 385 years before present was determined from wood 156 cm below the surface of the lake bed.

# # #

SOIL TEMPERATURES UNDER A BURNING CAMPFIRE
YOSE-N-1000

INVESTIGATOR: Dennis B. Fenn
National Park Service Science Center

SUMMARY OF PROGRESS: During this study, it was found that the natural water repellent layer in the surface soil beneath the organic duff layer can be broadened and intensified by the heat from an overlying campfire. This is most pronounced when the soil was initially moist, and the temperatures were thus kept at a lower level by the high heat of vaporization of soil moisture.

Coniferous fuels burn hot but very rapidly and cause only a short-term rise in the soil temperature. Deciduous hardwoods on the other hand form a long lasting coal bed and can cause the temperature of the soil profile down to at least 5 inches to rise well above 100°C for durations in excess of 50 hours. Such prolonged sterilization temperatures can greatly disrupt the microbial balance within a soil.

The organic matter quantity and quality can be significantly reduced in the surface 4 inches of the soil due to the intense heat from a campfire. This can greatly affect the soil structure, moisture relations, and fertility of the soil.

The results of this study demonstrate that from a soil point of view, it is best to restrict campfires to specified sites, preferably prepared fireplaces, rather than to allow random location of fire sites by the user. Coniferous fuels are less damaging to the soil due to their rapid and more complete consumption without a prolonged coal bed stage.

# # #

TAXONOMY OF THE GENUS *ALLIUM* (CALIFORNIA AND NORTH AMERICA)

INVESTIGATOR: Dale W. McNeal, Jr.
University of the Pacific

SUMMARY OF PROGRESS: Due to circumstances beyond my control, I was out of the United States from 1 May 1974 to 10 June 1974. After my return I was in the park on collecting trips twice but both trips were unsuccessful and no specimens of *Allium* were collected.

# # #

THE REPRODUCTIVE STRATEGIES OF SOME PLANT SPECIES RANGING IN ALTITUDE IN THE SIERRA NEVADA MOUNTAINS

INVESTIGATOR: Dorothy Douglas
University of California, Berkeley

SUMMARY OF PROGRESS: A description of this research project and the project design have been submitted.

Procedure 1 was developed during the summer of 1974, and will be modified for 1975 field work as described in the section on project design. The data obtained in 1974 is currently being examined and no conclusions are as yet available. Procedures 2 and 3 will be carried out in 1975 field work. Procedure 4 is currently under way, making use of the growth chamber facilities of the Botany Department of the University of California at Berkeley.

I am planning on one or two more summers of field work, depending on the results of the first summer. Laboratory work will continue during the academic years.

# # #

GENETICS OF GIANT SEQUOIA

INVESTIGATOR: Lauren Fins
University of California, Berkeley

SUMMARY OF PROGRESS: This past summer I collected giant sequoia cones in all three of the Yosemite groves. The majority of cones was collected in the Mariposa grove. Seed from these cones will be used in genetic analysis, on both a biochemical level and in clonal outplantings. Some of the seed will also be stored for gene conservation.

We are beginning to look at giant sequoia as a possible addition to the mixed conifer timber-growing resource of the Sierras. To date, no one has assessed the inherent variation in the species. The collection I made this summer will serve as a basic resource to investigate the genetic variation throughout the natural range of the species. Early biochemical work will begin in the spring of 1975 and the seedlings for future clonal outplantings will also probably be germinated sometime this winter or early spring.

We have no recommendations as yet. The groves preserved in Yosemite will play a major role in the current investigation. Any future findings will be made available to the parks as they become known.

# # #

YOSEMITE VERTICAL RESEARCH

INVESTIGATOR: Craig E. Douglas

SUMMARY OF PROGRESS: This study was started in the spring of 1974 with the objectives of investigating the ecology and biogeography of granite cliffs and to begin an inquiry into the impact now being sustained by these cliffs in recreational areas. The study is limited to those cliff areas in Yosemite Valley proper and has established three representative plot regions within this area. The plots themselves are highly stratified and occur on both north- and south-facing walls.

The study was designed to illuminate the sequential events of geologic formation of cracks through to the establishment of mature biotic communities. There is one unique aspect of the cliff environment which regulates all cliff processes; verticality.

During 1974 visual descriptions of all three plot regions were made according to geologic origin and habitat type. Vegetational inventories were made of two plot regions in which cover, relative abundance, and reproductive conditions were noted. In accordance with the collected data, accurate differentiations were made of the rock crack life phases which in turn aided inventory activities. Little was done with impact assessment save the "before" photographic documentation of specific climbing routes.

# # #

MOUNTAIN MEADOW DEVELOPMENT AND HYDROLOGY

INVESTIGATOR: Spencer H. Wood
California Institute of Technology

SUMMARY OF PORGRESS: This investigation of stratified soil beneath montane and subalpine meadows in Yosemite and Kings Canyon National Parks and Sierra National Forest contributes to the understanding of the origin and maintenance of mountain meadows. The basic requirements for an open meadow in a closed coniferous forest are: (1) shallow water table, and (2) drainage-basin geomorphic, hydrologic, and vegetation conditions that promote deposition rather than erosion of sandy-loam textured soils.

Soil-stratigraphic evidence suggests that snowmelt-fed seepage water delivered to valley bottoms was not so plentiful during intervals in the past. Water tables in some sites now occupied by meadows were formerly too deep to support a meadow. For example, in Tuolumne Meadows, the 1-3 ft of dark brown topsoil that accumulated under meadow conditions can be no older than 2500 radiocarbon years. Beneath the organic meadow soil are layers of clean alluvial sands and gravels, devoid of soil layers, resting upon glacial till. The sands and gravels do not retain soil moisture, and the roots of meadow plants cannot penetrate more than 2 ft. Therefore, to establish the meadow upon sand and gravel, the water table must have risen to the surface. It apparently rose to within reach of meadow plants only 2500 years ago.

# # #

RANGE SITE SOILS CORRELATION

ZION-N-0017

INVESTIGATOR: Lamar R. Mason
U. S. Department of Agriculture

SUMMARY OF PROGRESS: During 1974, the 9th year of our 10-year study in Zion National Park, we made follow-up range yield studies in locations where we had previously collected data. We are badly in need of data from four locations on the West Rim Trail, but due to National Park Service policy of not allowing vehicular traffic on the Potato Hollow road we were unable to get this data in 1974. Unless this policy is changed for 1975 we will conclude our study without this important information. It is too costly and time-consuming to get men and equipment to the locations where data is needed without use of motor vehicles into Potato Hollow.

The study will be concluded after one more year of field study. We will then prepare a publication showing the soils and vegetation associations for the locations we have studied in the park. This will include yield and composition of vegetation and information useful to both technically trained people and the environmentalists. We hope that it will also be useful to National Park Service personnel in nature talks to the visiting public.

# # #

BIGHORN SHEEP RESTORATION PROJECT

ZION-N-0002

INVESTIGATOR: Henry E. McCutchen
National Park Service

SUMMARY OF PROGRESS: To date, this small herd of desert bighorn sheep transplanted from Nevada have been in the 70-acre enclosure at Zion National Park for 18 months. The sheep have adjusted to the enclosure and have developed a daily routine. They have gone through a normal annual cycle of lambing, weaning, and mating. The sheep have preferred to feed upon the existing vegetation within the enclosure. Alfalfa hay and protein blocks are continuously available and have been intermittently used. The herd has not increased enough for a release.

In January 1974 there were 12 sheep present. These consisted of 3 rams, 5 ewes, 2 yearling ewes, and 2 lambs (born in December 1973). Two additional lambs were born in March 1974. In September 1974 one of the rams died of complications caused from a broken shoulder. In October 1974 another ram died. Milkweed poisoning was the suspected cause of death of the second ram. At present, 12 sheep remain in the enclosure. These consist of 1 ram, 5 ewes, 2 two-year-old ewes, and 4 lambs.

In August 1974 a biologist was added to the park staff. A study was initiated to determine the carrying capacity of the enclosure. More intensive studies have been initiated to determine the composition and utilization of the vegetation within the enclosure. Activity patterns and behavior are being documented. A plan for a release to the Zion ecosystem is being formulated. Potential release sites are being evaluated. Plans for research are being developed.

Desert bighorn populations appear to be declining throughout their present range. Recent studies have shown considerable potential habitat outside of the present range within areas of historical range. These areas are being considered as potential transplanting sites. There is a need for knowledge on all aspects of desert bighorn restoration. The research conducted on the Zion project will be of benefit to future desert bighorn restoration efforts.

ADDENDUM

BISCAYNE NATIONAL MONUMENT

COMPARISON OF MANMADE AND NATURAL REEFS
BISC-N-0007

INVESTIGATORS:	Richard B. Stone H. Wes Pratt R. O. Parker, Jr. Gary E. Davis
SUMMARY OF PROGRESS:	The goal of this project was to compare the number, species composition, and behavior of fishes on an artificial and natural reef and determine the feasibility of using artificial reefs to increase the fish carrying capacity near natural reefs.

The work began in January 1972 when a reef of 500 used automobile tires was built 300 yards northwest of Pacific Reef Light in the National Park Service's Biscayne National Monument. The area is subjected to east-west tidal currents up to one knot. The reef was constructed 40 ft in diameter and 7 ft high, utilizing the techniques developed by NMFS artificial reef program personnel. This approximated the size and shape of a natural coral patch reef 70 ft to the south which was the control study site. At this time a preliminary fish population count was made on the natural reef, photographs were taken, and 14 fish were trapped and tagged.

Edalhab II was deployed on 26 February 1972 when the artificial reef was 37 days old. The habitat was located 150 ft northwest of the tire reef. Three biologist/divers (Harold Wes Pratt, Kenneth Pecci, and Clifford Newall) spent 4.5 days in the habitat averaging 6 hours a day working on the study sites.

Species check lists were used to make 24 independent population estimates of the fish on both reefs. The reefs also were measured to obtain planar surface area for standing crop estimates. Approximately 900 still photographs were taken to aid in species identification. Final results reveal 143 individuals of 29 species adopted the artificial reef for permanent residence. Subadult and juvenile grunts, drums, and angel-fish comprised the bulk of the population. The natural reef study site contained 368 individuals of 38 species.

On 12 April 1972 the habitat was repositioned on the study site. Pratt, Frank Stiemle, and Roger Clifford, using the same techniques worked out during the February mission, examined the population structure of the two reefs. Richard Stone worked with the biologist from the surface. They noted many fish observed during the first mission as well as a number of new arrivals. Most of the population changes occurred on the tire reef.

Although a few tires had "bedded" into the sand, the position of the artificial reef was virtually unchanged. Approximately 1000 still photographs were taken to aid in species identification and population counts. Several of the nearby patch reefs were examined and fish counted to insure that the control reef was typical of the area.

The population of the tire reef had increased to 251 individuals of 51 species. This number does not reflect the number of gobies, but we did include them in the species category since we were able to determine which species were present but unable to make complete counts of individuals on all the missions. The natural patch reef community increased to 760 individuals of 58 species. Two spiney lobsters and many crabs and molluscs were observed on the artificial reef.

We conducted the rest of the missions without the habitat using SCUBA from surface vessels. Our August 1972 comparisons of the tire artificial reef with the similar size natural coral reef revealed about equal numbers of fishes on each reef but greater species diversity on the tire reef in daylight hours. The greater species diversity on the artificial reef was a result of pelagic visitors. There were 674 individuals of 56 species on the 7-month-old artificial reef and 668 individuals of 48 species on the natural patch reef.

Based on the results of the February 1972 mission, we anticipated a seasonal decline in the number of species and individuals observed on both study reefs during our February 1973 mission. This did occur with 43 species and 337 individuals counted on the artificial reef and 377 individuals of 37 species observed on the natural reef.

The number of individuals had increased considerably by our August 1973 survey. Most of this increase was caused by the occurrence of about 800 juvenile tomtate grunts on each of the study reefs.

The number of individuals on the study reefs was higher during our February 1974 survey than previous February missions. This again was attributable to the occurrence of a large number of juvenile tomtates on both reefs.

Because of rough seas, we counted the study reefs only once in April 1974. This probably accounts for the low number of species observed during this mission.

During our August 1974 mission on the FLARE Reef Study Site, we completed our study by counting both reefs and quantitatively harvesting the fishes on the artificial reef with rotenone. This enabled us to determine the standing crop on the artificial reef and provided a standard to evaluate our visual counts on both reefs. After harvesting the fishes, we removed all the artificial reef materials from the Biscayne National Monument and left the area essentially as it was prior to the construction of the reef.

We encircled the artificial reef with a fine mesh seine 49.7 m long and 6.1 m high prior to poisoning to reduce the chance of fishes escaping the rotenone. On the day of treatment, 21 August 1974, 27 people and five boats were involved in poisoning the artificial reef, collecting the fishes, and removing the reef material. The participants cooperating in this study came from the NOAA Atlantic Oceanographic Laboratories in Miami, Florida, NMFS Laboratories in Beaufort, N.C., Narragansett, Rhode Island, and Miami, Florida, National Park Service personnel from Biscayne National Monument and Everglades National Park, U.S. Geological Survey personnel from the Fisher Island Station, Miami, Florida, Department of Natural Resources biologists from the states of Georgia and South Carolina, local contractors, and the Miami Sprotfishing Club. NOAA's Manned Undersea Science and Technology Office provided partial funding for the study.

We are still checking the identification of several species and the results that follow should be considered preliminary and subject to change through further analyses. We collected 1495 individuals of 46 species with a total weight of 10,727 g. Our visual estimates of fishes on the artificial reef indicated 1078 individuals of 48 species present. The difference in the visual counts and the actual number of fishes collected was caused mainly by an underestimation of the number of juvenile grunts present on the reef. We did count gobies on this mission so the total number of individuals observed (1078) was higher than in August.

The artificial and natural reefs were similar in terms of number of individuals and species living on each reef. We plan a publication to describe the population structure of these reefs at a later date.

To determine the effectiveness of this artificial reef, we compared our biomass estimates, obtained by poisoning the reef and collecting all the fishes, with quantitative estimates of biomass per unit area obtained by other researchers on tropical and subtropical artificial and natural reefs. Although the artificial reef did not appear to be as productive as other artificial reefs we have studied, it had a higher biomass per unit area value than all but two natural reef areas described in the literature we reviewed. However, the FLARE artificial reef had a lower biomass value than all but one of the artificial reefs with quantitative values listed in the literature. Based on the preliminary results of this study, it would be feasible to increase fish carrying capacity near natural reefs with artificial reefs.

# # #

COMMUNITY STRUCTURE AMONG MEIOFAUNA OF TROPICAL CARBONATE BEACHES

BISC-N-13

INVESTIGATOR: William D. Hummon
Ohio University

SUMMARY OF PROGRESS: Collections, sorting, and faunistic counts have been completed with respect to the Gastrotricha of three beaches in Biscayne National Monument, two at Elliott Key and one on Adams Key. Fauna and its numerical relations with that from beaches of Key Biscayne; Bahia Honda; St. Thomas, American Virgin Islands; Massachusetts; and New York are discussed in a paper: Hummon, W. D. 1974. $S_{H'}$: A similarity index based on shared species diversity, used to assess temporal and spatial relations among intertidal marine Gastrotricha. *Oecologia* (Berlin) 17:203-220. Taxonomy of the Gastrotricha from the Floridian beaches will be written for publication during the spring of 1975 and a detailed analysis of their ecology will follow about a year later. Duplicate samples were preserved and have been retained for potential future use.

# # #

ECOLOGY OF MARINE ZOOPLANKTON

BISC-N-19

INVESTIGATOR: M. R. Reeve

SUMMARY OF PROGRESS: The phase of this study which involves field work within Biscayne National Monument has not yet commenced.

# # #

SEDIMENTARY PROCESSES AND GROWTH HISTORY OF CARBONATE MUD BANK

BISC-N-0020

INVESTIGATOR: E. Robert Warzeki

SUMMARY OF PROGRESS: The field work and laboratory work are complete. My thesis should be ready for defense in spring 1975, the first draft being 90% complete.

SIGNIFICANT FINDINGS: Bedrock configuration. Caesers Creek Bank lies over, and partially fills, a broad, shallow embayment in the gently seaward-sloping bedrock floor of the inner shelf margin, just east of the keys. This embayment measures 4 km from north to south; its floor is 5-7 m below sea level. The deep bedrock channel of Caesers Creek extends seaward nearly 1 km from the tidal pass before opening into the embayment. The last 0.5 km of this deep channel is buried beneath the southern margin of the present outer channel of Caesers Creek.

History of Caesers Creek Bank (summary). Caesers Creek Bank originated as a storm tidal delta similar in shape to that of Broad Creek. Within the past 1500 years, a southern branch of the outer channel was abandoned and filled in; all surface traces of it except for the point where it joined the present channel were erased by later erosion within the bank's interior.

Within the past 1000 years, in response to increased water agitation as the delta built up to within 1-2 m of mean low water, increased production of sediment by the bottom communities radically altered its shape. The long, narrow, coral-capped shoal on the southeast flank and the broad, shallow, muddy shoal which forms the southern tip of the bank were both produced by sediment by the bottom communities.

Aside from local production, the major source of sediment throughout the bank's history has been suspended detrital carbonate from Biscayne Bay. Most of this sediment was probably transported during major northerly storms and hurricanes which force water southward in Biscayne Bay and Caesers Creek.

Publication

Growth history and sedimentary dynamics of a mixed carbonate mudbank/tidal delta. Oral paper to be presented at the 1975 annual meeting of the Society of Economic Paleontologists and Mineralogists (SEPM) in Dallas, Texas, on 7 April 1975.

# # #

EFFECT OF HERBICIDES AND METABOLIC INHIBITORS ON CALCIFICATION

BISC-N-24

INVESTIGATORS: Dennis L. Taylor) University of Miami
Bruce E. Chalker)

SUMMARY OF PROGRESS: Studies relating to the above project were not carried out within the confines of Biscayne National Monument.

# # #

CARLSBAD CAVERNS NATIONAL PARK

IDENTIFICATION AND ECOLOGY OF MICROFLORA IN CAVES OF THE NATIONAL PARK SYSTEM

INVESTIGATORS: Donald E. Gardner) National Park Service Science Center
Brenda J. Little)

OBJECTIVES: The objective of the present study in Carlsbad Caverns was to determine what microorganisms are present and what interrelationships might exist, whether they are symbiotic, commensal, parasitic, saprophytic, or antagonistic. Carlsbad Caverns is the first cave to be studied in this manner, largely due to the fact that Mexican freetail bats and cave swallows roost in portions of the cave. Their litter provides an inoculum potential, as well as an immediately available substrate rich in nitrogen for bacterial and fungal growth.

METHODS: Samples of cave swallow droppings and bat guano, air samples, and scrapings of algae growing on formations were collected from Carlsbad Caverns. The cave swallow droppings were asceptically collected from nine locations near the entrance of the cave, away from the trails and undisturbed by visitor traffic. The specimens included dirt, rocks, feathers, and nest-building materials that had been transported to the nesting site. Samples were stored (collected) in sterile, cotton-plugged glass tubes until examined in the laboratory. In a similar manner, collections of fresh and old bat guano were made from various locations beneath the bat roosting area. The bat cave is not a part of the main caverns and is not frequented by visitors. Petri dishes containing potato dextrose agar and brain-heart infusion agar were exposed in areas throughout the caverns, including in the nesting areas and the lunchroom for a 24-hour period. Other similar plates were waved through the air.

Using a limiting-air orifice and a vacuum pump, one-liter air samples were collected in 25 ml of impingement fluid. The impingement fluid was then filtered through a 0.45 µ filter so that all microorganisms would be retained on the filter disc. Filter discs were then transferred to Petri dishes containing sterile solid medium and prepared for incubation. The airborne microorganism samples were collected near the entrance to the caverns under the cave swallow nests.

All plates were closed securely with tape, placed in plastic bags and kept in a cool place until they reached the laboratory. Plates for the isolation of fungi were incubated at room temperature, bacterial plates at 37°C. For the isolation of the microorganisms in the cave swallow debris and bat guano, the samples were suspended in sterile physiological saline (1 g/liter) and plated on a variety of growth media, including potato dextrose agar, water agar, esosin methylene blue agar, brain-heart infusion agar, mycosel agar, Sabouraud's agar, cornmeal agar, and Czapek agar and incubated at suitable temperatures. Quantities of the bat and bird guano were also plated directly on these media and incubated at appropriate temperatures. Cultures of fungi and bacteria isolated by these techniques were transferred to growth media and grown in pure culture for identification.

RESULTS AND DISCUSSION:

Our isolation procedures did not include the use of small laboratory animals or enriched blood media used specifically in the recovery of human pathogens, since our laboratory is not equipped for such procedures. However, no specific attempts were made to avoid the isolation of such organisms. According to the work of Kajihiro in 1965, eleven specific human pathogenic fungi were isolated from Carlsbad Caverns, including *Histoplasma capsulatum*, the causative agent for histoplasmosis.

The isolates from our various sampling stations were remarkably similar, indicating that the microflora of the bat cave does not differ markedly from that of the cave swallow roosts. The number of bacteria isolated from the bat guano is several orders of magnitude greater than that isolated from the cave swallow debris. The total plate counts were consistent with those reported by O'Brien and Raitt. The airborne bacterial and fungal counts at the entrance of the cave differed considerably. However, the counts were often so high that filter discs were completely overgrown with colonies after 24 hours incubation. The air samples were collected during a period of heavy visitor use and sampling stations were limited to accessibility of electrical plugs. The values that we are reporting for total coliforms are higher than those previously reported. The fecal coliform:fecal strep ratio of 0.70 is consistent with that normally associated with livestock and poultry wastes. None of these values indicate the presence of human wastes (Table 1).

The dominant fungal genera in terms of numbers of individual propagules per sample were identified as *Aspergillus*, *Penidiccium*, *Candida*, and *Scopulariopsis* in both cave swallow droppings and in the bat guano. *Aspergillus* and *Penicillium* are common inhabitants of all soil types. Their presence and quantity were predictable. *Scopulariopsis* is a soil saprophyte, and while it may not be an etiological agent of disease, it has been associated with nail infections and lesions associated with histoplasmosis. *Candida* is the causative agent of Candidiosis which manifests itself as thrush, mycotic vulvovaginitis, and bronchomycosis. The fungus *Cladosporium*, which causes skin infections, was also isolated. However, no specific pathogenicity can be attributed to our isolates until the species have been confirmed.

Bacterial isolates that have been identified include *Aerobacter aerogenes*, *Streptococcus* sp., *Staphylococcus*, *Escherichia coli*, and *Serratia marcescens*. The most prevalent organism isolated was *Serratia marcescens* which was present in air samples taken at the entrance of the cave and in the lunchroom, in soil samples as well as in bird and bat guano samples. This organism is easily identifiable because of a unique pigmentation characteristic. When incubated at room temperature, the strains are very deeply pigmented but the pigment is not produced when incubated at 35°C. When *Serratia marcescens* is growing, the pungent ammoniacal odor of trimethylamine is produced and probably contributes to the stench associated with the droppings of the cave swallows. *Staphylococcus* is associated with skin lesions and is ubiquitous in nature. The other isolates are commonly found in soil and fecal specimens.

Addendum

The alga *Protococcus* was recovered from rock surfaces near the cavern entrance within the range of natural sunlight. The alga was growing independently, and was not associated with any fungus. We also observed algae growing on formations opposite incandescent lights and contributing to the discoloration of these formations.

Our failure to isolate any given organism from our samples does not in any way preclude the possibility of its existence. The more fastidious organisms tolerate very little variance in temperature, humidity, and substrate encountered in transportation from collection site to laboratory. As mentioned earlier, it is highly probable that *Histoplasma capsulatum* is present in the cave. The organism has been isolated from droppings of domestic and cave-dwelling bat pigeons and chicken litter. In April 1963, Kajihiro reported that workers in Carlsbad Caverns were predominantly reactive to histoplasmin sensitivity tests. It is our suggestion that workers be regularly subjected to this simple procedure as a screening mechanism for exposure to *Histoplasma*.

Since bats and swallows are migratory in nature and not winter inhabitants of the cave, we suggest that a similar study should be undertaken during the winter months using the refinements of the techniques described here and concentrating on the energy flow in the caverns.

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# # #

Table 1. RESULTS

Sample/Location	Bacterial Count	Fungal Count	Total Coliform	Fecal Coliform	Fecal Strep.	Coliform Strep.	Salmonella
Cave Swallow Droppings:							
1) near entrance	$4.00x10^{6}$	NP	$8.6x10^{3}$	$5.3x10^{1}$	$7.2x10^{1}$	0.74	0
2) near entrance	$4.30x10^{6}$	NP	$7.3x10^{5}$	$4.0x10^{1}$	$4.0x10^{1}$	1.00	0
3) scraping from base of light	$3.20x10^{6}$	$3.9x10^{5}$	$1.7x10^{5}$	$4.6x10^{1}$	$6.2x10^{1}$	0.74	0
4) cliff under entrance	$2.00x10^{6}$	$5.8x10^{5}$	$8.6x10^{5}$	$2.9x10^{1}$	$3.8x10^{1}$	0.76	0
5) under nest	$1.10x10^{6}$	$2.0x10^{5}$	$5.0x10^{4}$	$3.7x10^{1}$	$5.0x10^{1}$	0.74	0
6) under nest	$1.30x10^{7}$	$6.0x10^{5}$	NP	NP	NP	NP	0
7) under nest	$3.40x10^{5}$	$3.0x10^{5}$	NP	NP	NP	NP	0
8) under nest	$2.60x10^{6}$	$5.0x10^{5}$	NP	NP	NP	NP	0
9) under nest	$9.60x10^{6}$	$5.0x10^{5}$	NP	NP	NP	NP	0
1-liter Air Samples: near entrance	too numerous to count	too numerous to count					
Bat Guano:							
Fresh:							
directly under roosts	$2.16x10^{9}$	$4.0x10^{4}$	$4.6x10^{3}$	$9.4x10^{1}$	$8.3x10^{1}$	1.13	0
directly under roosts	$5.04x10^{9}$	$6.0x10^{4}$	$8.7x10^{3}$	$8.6x10^{1}$	$7.6x10^{1}$	1.13	0
directly under roosts	$1.12x10^{9}$	$8.0x10^{4}$	$9.4x10^{4}$	$9.6x10^{1}$	$9.0x10^{1}$	1.07	0
Old:							
fringes of roost area	$1.00x10^{8}$	$3.5x10^{4}$	$5.7x10^{3}$	$3.9x10^{1}$	$3.0x10^{1}$	1.30	0
fringes of roost area	$4.00x10^{8}$	$2.0x10^{4}$	$3.0x10^{4}$	$4.2x10^{1}$	$3.9x10^{1}$	1.08	0
fringes of roost area	$3.20x10^{8}$	$3.0x10^{4}$	$8.4x10^{3}$	$7.8x10^{1}$	$6.0x10^{1}$	1.30	0

NP - Analysis not performed.
Results are average of five replications.
Results represent counts per gram of sample - guano, soil, etc.

EVERGLADES NATIONAL PARK

THE ENCROACHMENT OF *SCHINUS TEREBINTHIFOLIUS* IN EVERGLADES NATIONAL PARK

INVESTIGATORS: G. Jay Gogue)
Charles Hilsenbeck)
Clyde J. Hurst)
Garry Bancroft)
National Park Service Science Center

OBJECTIVES: To describe the extent of the encroachment of *Schinus* into Everglades National Park, and to consider the potential threat of this exotic to native plant communities.

INTRODUCTION: Brazilian pepper tree (*Schinus terebinthifolius* raddi) is an evergreen Anacardiaceous tree that was introduced into Florida in the late 19th century. The exact entry date of *Schinus* is not known but it was found in Bradenton, Florida in about 1892. Soon after its introduction, it became apparent that *Schinus* could withstand a wide tolerance of environmental stresses, such as soil type and pH, high salinity, drought, flooding, fire, etc. *Schinus* also exhibited a rapid growth rate and a high sexual regenerative capacity. Due to these characteristics and the attractiveness of the fruit as an ornamental, *Schinus* became popular in Florida landscapes in subsequent years.

In the last 50 years, *Schinus* has become greatly dispersed throughout much of the Florida peninsula. Unfortunately, this dispersal has not always been under selective control, and as a result *Schinus* disseminules are now found in many areas where their presence is undesirable. Birds (within a wide range) and small mammals (within a limited range) have been very significant agents in disseminating *Schinus*. After the fruit is consumed, the small, brown seed is passed through the animal's alimentary system, becomes scarified, and is deposited wherever the animal defecates, often resulting in further establishment of *Schinus*.

The purpose of this work was to describe the extent of the encroachment of *Schinus* into Everglades National Park and to consider the potential threat of this exotic to native plant communities.

RESULTS AND DISCUSSION: *Schinus* was first observed in the park in 1955. Since the initial entry, it has spread to numerous locations within the park, with frequent additional sightings; however, the majority of the *Schinus* is found in 10 separate locations. Figure 1 represents the geographic location of these areas of known *Schinus* stands within the park boundaries in September 1974. The areas inundated by *Schinus* total approximately 5000 acres.

In an effort to determine whichever land type has been encroached upon most readily, five discrete, physiographic areas (pine woods, wet prairies, farmlands, farmland prairies, and buttonwood-mangrove lands) were chosen for study. A detailed description of each area is presented in Table 1. Within each area, five plots of 5 X 20 m size were randomly selected for sampling. Species-area curves that were generated for each series of plots using all species present indicated that the sample size used was adequate. Analyses were conducted for frequency, density, and percent cover, with the *Schinus* population subdivided into five classes according to height: (A) 0.00-0.49 m, (B) 0.50-0.99 m, (C) 1.00-1.49 m, (D) 1.50-1.99 m, and (E) greater than 2.0 m. Only *Schinus* greater in height than 1.5 m are capable of sexual reproduction.

Approximately 3% of the pinewoods studied were covered by *Schinus* with a total density of 706 *Schinus*/acre. A high percent of the B- and C-class plants are located in the numerous solution holes, where they grow unharmed by periodic fires. Most A- and B-height *Schinus* were located away from these holes and consequently they showed fire damage. *Schinus* distribution in the pinewoods indicated that the interaction of natural fires and solution holes have been very significant in establishment of localized *Schinus* communities. Probably the importance of the solution holes will diminish as the *Schinus* become reproductive, since mature *Schinus* do not readily support combustion. Entry of *Schinus* seeds into the pinewoods is probably due to bird-linked dissemination from reproducing plants located 100 yards east of the pinewood plots. The pinewoods seem to offer a prime site for *Schinus* understory development perhaps with a gradual crowding out of existing native understory vegetation.

In the wet prairie, the density for C-, D-, and E-height *Schinus* is much greater than in the adjacent pine land, probably indicating a more favorable habitat for growth with less competition from other vegetation, more available water, and probably less fire damage during the initial *Schinus* development. *Schinus* in the wet prairie covered approximately 14% of the land area and comprised a density of 408 plants/acre.

In the farmlands, the *Schinus* density is 14,376 plants/acre with A-height plants accounting for most of the population. The densities of the reproducing plants (D and E) are 160 and 176 plants/acre, respectively.

The *Schinus* population in the farmlands is in established communities composed of numerous young plants and many reproducing plants. *Schinus* accounts for 75% of the vegetation cover in the farmlands. From the 1940s through the late 1950s, this land was extensively farmed in vegetable crops. After farming ceased, a series of successional plant communities undoubtably developed, but by 1971 the area was composed mainly of exotic plants, with *Schinus* dominating (Figure 1).

Schinus has not rapidly spread into the farmland prairie, even though it is immediately adjacent to the large, reproducing population in the farmlands. The total *Schinus* density of the farmland prairie is only 40 plants/acre, and nearly all of these plants were located adjacent to several pine and hardwood islands. These trees probably provided a convenient perch for birds, thus allowing *Schinus* dissemination from bird defecates. Total *Schinus* cover is less than 1% in the farmland prairie.

Young, non-reproducing *Schinus* have become well established in the buttonwood-mangrove lands. The plots for this land type were located on the extreme southwestern portion of the park and as such they were surrounded by natural barriers of water and vast acreages of park land. As a result, bird dissemination of *Schinus* would have to occur from the few reproducing *Schinus* which are located within the park (approximately 20 miles away) or from the numerous reproducing plants located outside the park boundary (40-60 miles away). Even with these logistical problems, the total *Schinus* density in the buttonwood-mangrove community is 3520 plants/acre with the total cover equaling approximately 30%.

These initial observations reveal several trends in *Schinus* encroachment:

1) The vast majority of the *Schinus* in the park is still young and therefore not yet capable of sexual reproduction. This indicates that *Schinus* encroachment in the park at this point has occurred mainly from reproducing plants located outside the park boundary. In the future, as the young plants become reproducing sources within the park, the number of *Schinus* will greatly increase and will undoubtedly alter existing native plant communities.

2) *Schinus* exhibited a high tolerance for five major land-plant types in the park. *Schinus* has become well established in all natural plant communities studied, as well as the farmlands, and has already reached sexual maturity in the wet prairie. Disturbed areas such as disbanded farmlands, roadsides, canal banks, etc., seem to be prime sites for *Schinus* establishment, but the natural areas, too, are effective supporters of *Schinus* growth.

3) The aggressive growth characteristics of *Schinus* have been documented (1) and indications are that native vegetation in Everglades National Park and throughout South Florida is threatened as *Schinus* becomes a dominant species in this area.

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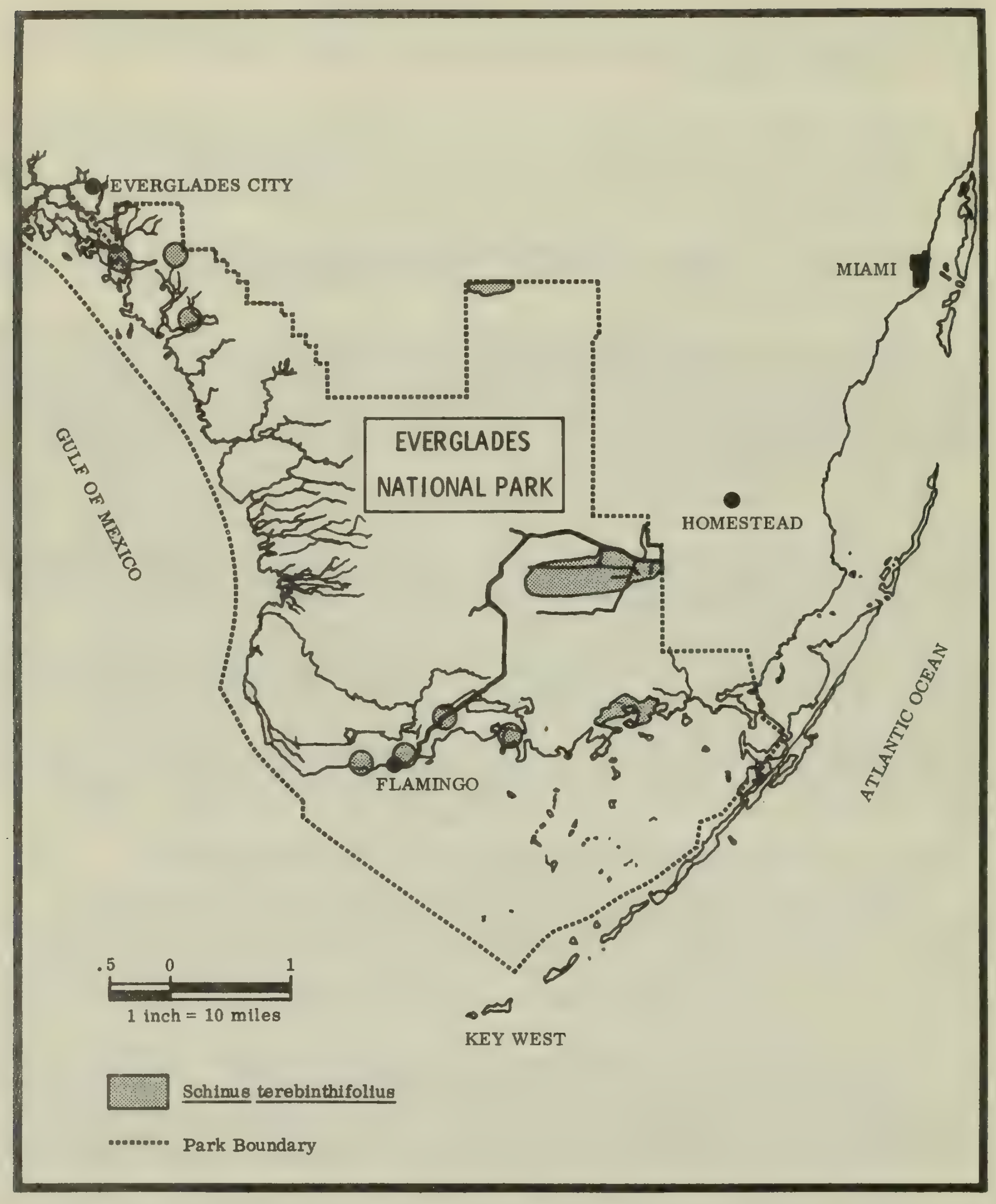
EVERGLADES CITY
MIAMI
EVERGLADES
NATIONAL PARK
GULF OF MEXICO
HOMESTEAD
ATLANTIC OCEAN
FLAMINGO
.5
0
1
1 inch = 10 miles
KEY WEST
Schinus terebinthifolius
Park Boundary

FIGURE 1.

TABLE 1.

Pine woods	Typical South Florida rockland pine woods; the understory consists of broadleaf hardwoods while the ground cover is mixed grasses and herbaceous flora; some litter overlies the dissected oolite rock; solution holes are numerous, and several contain aquatic and marsh vegetation such as *Cladium jamaicensis, Sagittaria lanceolata, Salix nigra,* and *Proserpinaca palustris* (L.).
Prairie	Composed chiefly of sedges, grasses, and herbaceous plants; some palms, swamp hardwoods such as *Chrysobalanus icaco, Persea borbonia,* and *Salix nigra,* and several mesic hardwoods such as *Metopium toxiferum, Conocarpus erecta,* and *Pisonia longifolia* are found in and around the numerous solution holes; there is no standing water except that in the solution holes, and the soil is thin marl overlying oolite rock.
Farmland	All natural plant associations were removed by clearing and burning, and the underlying rock was crushed and mixed with the marl; depending upon the time of farmland abandonment, a wide range of successional stages is present; exotic species such as *Schinus, Ardisia solanacea, Sesbania sericea, Eleusine indica, Dactyloctenium aegyptium,* and *Rhynchelytrum repens* are widely distributed; the main vegetation community is composed of *Baccharis halimifolia, Schinus, Ampelopsis arborea, Vitis rotundifolia,* and *Thelypteris kunthii;* the ground is furrowed without standing water; very little litter is present; the soil is marl mixed with oolite rock chunks.
Farmland Prairie	This area is dominated largely by *Muhlenbergia filipes* with occasional clumps of *Cladium jamaicensis* and *Panicum* sp.; herbaceous plants are widely scattered while hardwoods are rare; *B. halimifolia* are occasionally found; the soil is marl, without standing water except in small, scattered solution holes, and the substratum is dissected oolite rock.
Buttonwood-mangrove Community	Characterized by dense shade, high humidity, seasonally fluctuating salinities, and a lush growth of epiphytes; the overstory vegetation is composed mainly of *Conocarpus* and *Rhizophora* with some *Rhabdadenia* sp. and *Urechites lutea*; the understory is comprised of scattered *Cladium jamaicensis, Acrostichum* sp., and *Mikania batatifolia*; on slightly elevated areas, a few hardwood seedlings are found; a thin humus mulch is overlying marl containing large amounts of broken shells of marine gastropods (*Cerithium*) and bivalves (*Donex*); standing water is present over about 40% of the ground; epiphytes found include: *Polystachia luteola, Encyclia tampense, Tillandsia balbisiana,* and *T. Flexulosa* are abundant on both *Conocarpus* and *Rhizophora.*

# # #

GROWTH INHIBITION BY *SCHINUS TEREBINTHIFOLIUS*

INVESTIGATORS: G. Jay Gogue)
C. J. Hurst) National Park Service Science Center
Larry Bancroft)

OBJECTIVE: To determine if *Schinus* exerts an allelopathic (non-competitive) phenomenon.

MATERIALS AND METHODS: *Schinus* organs (stems, leaves, fruit, and litter) were randomly selected from eight locations in Everglades National Park during the fall, winter, spring, and summer seasons. The various plant organs (500-g sample) were individually placed in a funnel container and covered with distilled water for 1 hour, 12 hours, 24 hours, 48 hours, or 96 hours. Specific organ leachates respective to given time intervals were collected with subsequent filtering of trash and debris. Next, 2 ml of the leachate which supplied the moisture necessary for germination was deposited on the bioassay seeds, Ripgut brome (*Bromus rigidus*). The radicle length was measured after 3 days and after 5 days the percent germination was recorded.

RESULTS AND DISCUSSION: Various *Schinus* organs soaked for 24 hours exhibited seasonal allelopathic effects. The greatest allelopathic phenomenon was observed from plant parts collected during the winter; while in the spring season *Schinus* did not appear to be allelopathic. The fruit was the most toxic plant part studied. The radicle growth from the fruit leachate was suppressed to about 1.1 mm while radicle growth in the control was approximately 20 mm, a reduction in length of 19 mm. We did not know whether 24 hours was an ecologically appropriate time period, so bioassays with various lengths of fruit soaks were initiated with germination and radicle length recorded. Germination was reduced by 12% from a single rinse. The control radicle length was reduced by approximately one-third with a single rinse, so we feel that rain falling on these various plant organs and then falling to the ground is toxic enough to inhibit or reduce germination and/or radicle elongation.

In the next experiment, various concentrations of *Schinus* fruit leach were used with a longer period of time allowed for germination. In the previous experiment, we noticed that some of the seeds that had received the high concentration leach (most lengthy soak) did begin to germinate after about 7 or 8 days. This would indicate that the compound(s) present in the fruit retarded germination rather than inhibited germination. After conducting this experiment, we concluded that the toxic material present in the fruit not only inhibits germination, but also retards it to some extent.

Blade lengths of *Bromus rigidus* that were subjected to water and dilutions of *Schinus* fruit leachates were measured after 1, 2, and 3 weeks. The lowest concentrations of *Schinus* leaches resulted in greatest blade lengths and vice versa. These data further substantiate the allelopathic mechanism present in *Schinus*. In a case where the bioassay plant received water one week prior to being subjected to the treatment of *Schinus* fruit leachates, it became obvious that the allelopathic effect is much less significant on established vegetation. This probably indicates that *Schinus* invasion into existing stands of vegetation will be much slower than in cleared areas such as roadsides. However, the data clearly indicate that if *Schinus* is allowed to become established it will in time exert its allelopathic effect.

CONCLUSIONS: This area of research is still being pursued, but there are currently four conclusions that can be drawn from these findings: (1) *Schinus* is allelopathic; (2) the allelopathic response is seasonal; (3) the phenomenon observed in the field can be accounted for by the allelopathic nature of *Schinus;* and (4) there is differential toxicity with respect to plant organ, with the fruit being the most toxic organ studied.

# # #

IDENTIFICATION OF ALLELOPATHIC MATERIALS PRESENT IN *SCHINUS TEREBINTHIFOLIUS* FRUIT LEACHATES

INVESTIGATORS: G. Jay Gogue)
Clyde J. Hurst) National Park Service Science Center
Dennis B. Fenn)

OBJECTIVE: To identify the compounds responsible for the allelopathic phenomenon exhibited by *Schinus*.

MATERIALS AND METHODS: Leachates from *Schinus* fruit that had soaked in distilled water for 24 hours were spotted on numerous thin-layer chromatography sheets (TLC). The TLC sheets were commerical precoated plates, Silica gel G of 250 μ thickness with a binder. The solvent system used for separation was butanol:acetic acid: water in a volume ratio of 6:1:2. The TLC plates were heated in an oven for 30 minutes at 100-105°C for activation. After the plates were cooled to room temperature in a disiccator, fruit leach samples were applied on the plates with a platinum loop (about 3 μl for each application). The plate was placed in a developing tank which contained 100 ml solvent. After 3 hours, the plate was removed from the tank and air dried. Various reagents were used for the location of the separated fractions. Also, mass spectrometry, infrared spectroscopy, and micro-histochemical procedures were used for supporting evidence for structure identification.

RESULTS AND DISCUSSION: Each leach spotted on the TLC plates separated into nine spots or fractions. Each of the spots was individually removed from numerous plates and stored until enough material (after removal of the Silica gel) was present to conduct microbioassays with *Bromus rigidus*. Three of the nine spots were toxic. Of the three spots, spot two (spot one is the origin) was very mildly toxic and was discarded at this time since spots number eight and nine were extremely toxic. In an attempt to identify these compounds, various detection reagents were used (Table 1). The type compounds the reagents detect and the various colors they indicate, as well as the response of the *Schinus* leach, is indicated in Table 1. Spots eight and nine reacted the same with the detection reagents, so in Table 1 they are simply referred to as *Schinus* leach. This is not uncommon, as these detection reagents have a very broad spectrum. However, with this process followed by a literature search, the number of possibilities was greatly reduced. We had determined that two materials (gallic and ferulic acid) were implicated in other allelopathic studies and also these materials gave similar detection colors to that of the *Schinus* fruit leach. Also, from further spotting it was found that gallic and ferulic acid had Rf values that corresponded to spots eight and nine respectively.

With the use of the mass spectrometer, spots eight and nine were analyzed with respect to content. Both gallic and ferulic acid were found to be present. However, the concentrations of gallic and ferulic acid were probably not sufficient to account for the phenomenon observed in the field. Infrared spectroscopy did not indicate gallic or ferulic acid to be present; however, the limits of detection with this technique are low.

From micro-histochemical studies with the transmission electron microscope of the *Schinus* leach treated racicle of *B. rigidus*, it was observed that a dark osmiophilic layer was present in the secondary cell wall. This indicates that phenols are present in this area. This was the only difference that was noted between treatments and controls.

In conclusion, a strong case can be made for gallic and ferulic acid (phenols) as a source of induced toxicities but this work is not conclusive.

Table 1. COMPARISON OF DETECTION REAGENTS WITH *SCHINUS* LEACHATES

Detection Reagents	Type of Compounds	Color	*Schinus* Leachates
Conc. H_2SO_4	Organic compound (small molecules black and large molecules brown)	Black to Brown	Black*
$FeCl_3.K_3Fe(CN)_6$	Phenols	Blue	Blue*
I_2 vapor	Unsaturated compounds	Brown	Brown*
Paul's Reagent NaOH	Phenols	Yellow	Yellow*
Paul's Reagent KOH	Aromatic amines	Orange	
Phosphomalylidic acid	Bile acids Glycerides Unsaturated fatty acids	Blue	Black
Dragendorff's Reagent	Alkaloids and choline comp'd	Orange	--
Ninhydrins	Amino acids Amino phosphates Amino sugars	Blue	Blue*
Rhodamine	Lipids	Purple	Light Purple

# # #

GREAT SMOKY MOUNTAINS NATIONAL PARK

MIMOSA WILT: CONTROL OF PLANTS THROUGH NATURAL DISEASE

INVESTIGATOR: Donald E. Gardner
National Park Service Science Center

SUMMARY OF PROGRESS: An experimental plot for the study of mimosa wilt was established. Two-year-old, disease-free trees were obtained commercially and these were set out in the field in a series of predetermined treatments and replications. Treatments included stem-injection with inoculum under pressure, dipping the roots in inoculum, and mixing inoculum in the soil near the roots. Control trees for each treatment were similarly treated but without inoculum. Observation of the inoculated trees is continuing.

# # #

ANAKEESTA ACID POLLUTION STUDY GREAT SMOKY MOUNTAINS NATIONAL PARK

INVESTIGATOR: Dennis B. Fenn
National Park Service Science Center

OBJECTIVES: (1) To determine the seasonal variation of acid discharge into Beech Flats Creek, Walker's Prong Creek, and Forney Creek; and (2) to determine feasible methods of alleviation of the acid dishcarge problem in Great Smoky Mountains National Park.

SUMMARY OF PROGRESS: Six portable recording pH meters have been purchased and they have been fitted into specially constructed waterproof fiberglass cases. These meters have been field tested at the NPS Science Center and they are undergoing laboratory testing under variable temperature conditions at the present time. Once reliability and operational stamina have been established, the meters will be ready for on-site deployment in the park.

PLANS FOR 1975: The meters will be installed on the selected streams in the park and the fluctuation in pH with weather and seasonal conditions will be monitored. Plans call for this monitoring to continue for one year. If adequate funding is available in Fiscal Year 1976, the remainder of the study aimed at devising suitable ameliorative techniques will be undertaken.

# # #

GULF ISLANDS NATIONAL SEASHORE

THE INTERACTION OF HERBICIDES, BRICK, AND MORTAR FROM FORT PICKENS, GULF ISLANDS NATIONAL SEASHORE

INVESTIGATORS:
D. Fenn)
W. Anderson)
R. Burge) National Park Service Science Center
R. Pickett)

OBJECTIVES: This research was undertaken to determine: (1) how herbicides may affect brick and mortar of an historically significant fort, and (2) if the herbicidal capacity of the applied chemical is affected by being applied to fort material.

METHODS: A small portion consisting of 10 bricks held together with "original" mortar was removed from a deteriorated section of Fort Pickens. Pieces of brick and mortar from this portion were soaked one week in a herbicide solution. Two herbicides, "Roundup" (isopropylamine salt of glyphosphate) and "Tordon 101" (10.2% 4-amino-3, 5,6-trichloropicolinic acid; 39.6% 2,4-dichlorophenoxyactic acid; 50.2% inert material) were used in 1 herbicide:1 water solutions. After soaking, herbicide-brick-mortar interactions were evaluated by: (1) comparing the resistance to crushing, crumbling, and abrasion of soaked material with nonsoaked material; (2) measuring the effect of herbicide residue on the brick-mortar on germination of brome (*Bromus rigida* L.) and radish (*Raphanus sativus* L.) seeds; and (3) observing the effectiveness of herbicides leached from soaked material on seedlings of radish, muskmelon (*Cucumis melo* L.), and Brazilian pepper tree (*Schinus terebinthifolius* Raddi).

Resistance of mortar to crushing and crumbling was evaluated by a tactile test where small amounts were rolled between the thumb and fingers. A similar method using thumb-pressure abrasive force was used to determine the effect of the herbicides on brick surfaces.

To determine the effect of brick and mortar on herbicidal effectiveness, pieces of soaked brick and mortar were air dried and crushed into pieces no larger than 3 mm on a side. About a 50 g quantity of crushed material was placed in a Petri dish and moistened with 20 ml distilled water. Seeds of brome and radish were incubated on filter paper disks on top of the moistened, crushed samples for one week. Failure of seeds to germinate was used as a basis of evaluating herbicidal activity. Germination was determined by emergence of the radicle from the seed.

Air-dried birck and mortar that had been soaked in herbicide solution were agitated 10 minutes in 50 ml distilled water on an oscillating shaker to further evaluate the effect of brick and mortar on herbicidal activity. The solution was decanted and applied to radish, muskmelon, and Brazilian pepper tree seedlings. All plants were sprayed with the solution until run-off.

RESULTS AND DISCUSSION: Mortar and brick soaked in 1 herbicide:1 water retained as much resistance to crumbling, crushing, and abrasion, as measured by tactile tests, as nonsoaked brick and mortar.

These experiments were performed in the spring of 1974, just prior to the time a mason was to join the staff at the Florida Unit of Gulf Islands National Seashore. The need for immediate information necessitated performing tests that provided empirical judgments that were not strictly quantifiable.

Mortar soaked in 1 herbicide:1 water solution of Roundup and Tordon 101 was as resistant to crumbling and crushing as nonsoaked mortar. Surfaces of herbicide solution-soaked brick were as resistant to crumbling and abrasion as nonsoaked brick surfaces.

It has been reported that some herbicides are rendered ineffective by clay micelles; however, these experiments with Roundup and Tordon 101 indicate these chemicals retain their herbicidal activity upon being applied to brick and mortar from Fort Pickens. The 1:9 dilution used for the herbicides was about 20X and 10X less dilute than the recommended strength for field application for Roundup and Tordon 101 respectively. Neither herbicide was rendered totally ineffective either against germination of radish and brome seeds or killing seedlings of radish, muskmelon, and Brazilian pepper tree. However, Roundup, a nonselective herbicide, was more effective against monocotyledenous seeds than Tordon 101. The latter is recommended for control of broad-leafed weeds in grasses.

Both herbicides retained effectiveness against herbaceous dicotyledons after being leached from brick and mortar. Leaves of the wood dicotyledon, Brazilian pepper tree, were killed by herbicide leached from brick and mortar, but the dilution was too great to cause death of the seedlings.

# # #

GLACIER BAY NATIONAL MONUMENT

OBSERVATIONS OF GLACIER VARIATIONS IN GLACIER BAY WHICH WAS PART OF A PROJECT COVERING OTHER AREAS IN THE PACIFIC MOUNTAIN SYSTEM OF SOUTHERN ALASKA

INVESTIGATORS: Richard H. Ragle) William O. Field) American Geographical Society

SUMMARY OF PROGRESS: The program of the American Geographical Society's party in 1974 was to continue the observations begun in 1926 and continued in 1935, 1941, 1950, 1958, 1961, 1964, 1966, 1967, 1968, and 1971. In each of these years the principal glaciers in Glacier Bay were examined to determine the changes that had occurred since the previous visit. Lack of time in 1974 prevented observations of the glaciers draining into Taylor Bay and the western slopes of the Fairweather Range.

In recent years data on these areas have been obtained mostly from a study of aerial pictures.

Beginning with Reid's visit in 1890, a photographic record has been made of identifiable sites. Our own work has carried on this record, using some sites which date from Reid's visits. Albums of our photographs, showing the changes in the glaciers from 1926 to 1961 are on file at Monument Headquarters in Bartlett Cove. A second series continuing our record from 1961 to 1974 is now being assembled. Such photographs are especially useful in recording the condition, appearance, and position of the glaciers in different years. They remain as a permanent record which can be referred to in future.

As the positions of glacier termini change, new photographic stations have been established and others which are no longer useful have been abandoned. In 1974 a total of 34 photo stations were occupied in Glacier Bay of which 5 were newly established that year. The number of these stations in each inlet is as follows: Muir 8, Wachusett 3, Queen 2, Rendu 4, Tarr 5, Johns Hopkins 4, Lamplugh 2, Reid 1, Hugh Miller 3, and Geikie 2. Other pictures, which also provide a useful record, were taken from the NPS M/V *Nunatak*. The position of the termini and the condition of the lower parts of 26 active glaciers and 2 remnant glaciers were determined. In addition, surveys employing simple triangulation and based on the same sites used as photographic stations were carried out in six inlets (Muir, Wachusett, Tarr, Johns Hopkins, Hugh Miller, and Geikie). These covered the termini of 12 glaciers. The associate in 1974 was Richard H. Ragle, then associated with the Arctic Institute of North America.

The present trends in the behavior of the glaciers appear to be as follows: all the glaciers of Muir, Wachusett, Queen, Hugh Miller, and Geikie inlets are shrinking. In contrast, the glaciers in Rendu, Tarr, Johns Hopkins, and Reid inlets in the northwestern part of Glacier Bay are either relatively stable, oscillating, or advancing. This strongly suggests that conditions in the drainage basins east of the bay, consisting of the Muir Inlet complex and Queen Inlet and those in the mountains west of the lower bay in the Hugh Miller and Geikie inlet basins, are still unfavorable for maintaining the present extent of the glaciers. All signs point to a continuing recession in these areas but probably at a slower rate than in the last few decades. On the other hand, conditions from Rendu Inlet around the head of the northwestern arm of Glacier Bay to the northern outflows of the Brady Glacier system are more favorable for the glaciers so they are close to a state of balance and in some cases are expanding.

The principal difference in the glaciers of these areas appears to be the altitude of their zones of accumulation. The glaciers whose main sources are neves and basins at relatively low altitudes, 3000-4000 ft, are tending to recede, whereas the glaciers originating primarily at higher altitudes are tending to be either stable or are advancing.

The glaciers which advanced between 1971 and 1974 were the Grand Pacific and Margerie in Tarr Inlet; the Johns Hopkins, Toyatte, Hoonah, and Lamplugh in Johns Hopkins Inlet; and the Reid, in Reid Inlet. The long term advances are those of the Grand Pacific which has been advancing since the late 1930s, the Johns Hopkins since 1929, and the Lamplugh since 1941. Whether they reflect positive mass balances of each glacier or a reduction of terminal ablation due to the development of submerged bars or end moraines is not known. It may be a combination of both factors. The advances of the other glaciers are of the spasmodic kind and therefore considered short term.

Several glaciers in Glacier Bay are known to have surged over the last few decades. Two were surging in 1974, the Toyatte in Johns Hopkins Inlet and the Tenas Tikke, occupying a tributary valley of Grand Pacific Glacier which is in British Columbia, outside the monument. The other glaciers which had surged in the 1960s, the Carroll, Rendu, and Tyeen, in 1974 were undergoing a post-surge condition of stagnation in their lower courses. If their periodicity of surge over the last few decades is maintained, the Rendu should surge again about 1980, the Tyeen about 1984, and the Carroll about 1990.

RECOMMENDATIONS: The record of detailed observations dates from 1884 in Muir Inlet and 1892 in the rest of Glacier Bay. Yearly, or at least fairly frequently, observations should be continued and supported by a photographic record from the most advantageous sites in each inlet. When significant changes occur, such as rapid recession or continuing advances, more detailed observations, including surveys, can be carried out. The glaciers which oscillate, whether surging or not, should also be watched to determine whether their oscillations may be related to common meteorological factors or their own periodicity.

There is a form of advance which needs to be kept under investigation, as it may indicate a significant mechanism which is largely independent of climatic factors. Such advances may be due to the reduction of the rate of terminal ablation (calving and melting at the water-ice interface) by shoaling due to sedimentation and the formation of submerged moraines in front of tidal glaciers. When the rate of terminal ablation is reduced, the glacier, if in approximately stable or balanced condition, will tend to advance until terminal ablation balances the forward movement of the ice.

Because it is usually dangerous and impractical to make soundings close to an active tidal terminus, the presence of such shoals or bars are often difficult to detect. However, recent soundings by the Geological Survey from a remote-controlled skiff indicate shallow water in front of a number of stable or advancing ice fronts that, from a distance, appear to rest in deep water. In some instances, the formation and extension of such bars can be seen to be developing over the years at such tidal ice fronts as the Grand Pacific and Lamplugh, both of which have been advancing.

Such a change at the terminus may affect the whole lower part of the glacier, and indeed may be cumulative in favoring a trend of advance. This process could conceivably be a significant causative factor in accounting for the advance of the main trunk glacier to the mouth of Glacier Bay, as has happened within the last two millenia. The phenomenon is not confined to Glacier Bay. It may occur at other tidewater glaciers in such areas as Yakutat Bay, Icy Bay, Prince William Sound, and along the southeastern coast of the Kenai Peninsula. However, Galcier Bay National Monument is one of the best localities for further investigation.

Continued studies of the geological and botanical history of the whole monument should be continued. The excellent work of Dr. Lawrence and the Institute of Polar Studies parties in the Muir Inlet and Lituya Bay areas have shown the potential of this approach. Haselton's work in Tarr Inlet, which is in an area presumably close to the fountain head of the great trunk glacier which filled Glacier Bay during the last 2000 years, merits continued support. Such studies should be extended to Geikie, Hugh Miller, Charpentier, and Wachusett inlets to determine the origin of the extensive deposits of stratified gravels and to work out the sequence of events that occurred in those areas during the last few millenia and the period of rapid recession in the 18th and 19th centuries.

The more difficult studies, but necessary to an understanding of the regimen of the glaciers, are those in the areas of accumulation. Such observations are difficult to make and are logistically complicated. Pending initiation of detailed high level observations, we recommend a series of systematic annual photo flights over the glaciers to determine the positions of the firn limit just prior to the first fall of winter snow. The first part of September should be a satisfactory time for gathering such data, but if the month of September is unusually warm additional later flights would be desirable. However, if flying facilities are limited, a series of flights either late in August or early in September would undoubtedly produce significant results in determining the approximate position of the seasonal firn limit during that particular glacier budget year. These data can then be correlated with the meteorological records now being recorded at Bartlett Cove and other stations in the general vicinity of Glacier Bay.

When support can be obtained, detailed glacio-meteorological studies should be initiated to determine further data on regimen, mass balance, and the response of the glaciers to observed meteorological variations. In addition to the deployment of summer filed parties, it would also be desirable to establish automatic meteorological stations in the upper reaches of Glacier Bay, both near sea level and on the ridges from 4000 to 6000 ft, to record conditions in the lower zone of the accumulation area.

Related to the glaciological observations, but to be performed by scientists in other disciplines, are the observations of the biological, geological, and climatological changes which are occurring in the transition of much of the monument area from glacial to non-glacial conditions. Such studies have broad application in other parts of the world. However, Glacier Bay is one of the best places to conduct this type of long term, systematic inquiry.

Glacier Bay continues to provide one of the finest areas in the world to study and explain many aspects of the processes of glaciation. Among the glaciological problems of immediate interest are: (1) the tremendous advances and recessions of the last 2000 years; (2) the contrasts in the behavior of the glaciers in the monument during the last 2 to 3 centuries; and (3) the causes of the contrasting behavior of the glaciers in various parts of the monument during the last 4 decades.

As these studies proceed, it should be increasingly practicable to make useful predictions, for planning purposes, of what may be expected to occur in the next few decades. This may be quite important to the National Park Service in its planning of future activities.

# # #

LAVA BEDS NATIONAL MONUMENT

FIRE HISTORY AND ECOLOGY OF LAVA BEDS NATIONAL MONUMENT
LABE-N-0017

INVESTIGATORS: Robert E. Martin) Arlen H. Johnson) University of Washington

SUMMARY OF PROGRESS: Research activities during the past field season were directed primarily toward developing the pre- and post settlement fire history of Lava Beds National Monument.

Records maintained at the monument headquarters were examined and portions of those records containing data and/or information regarding fire occurrence were transcribed. Although data and information contained in these records covers only approximately the past half century, analysis should provide basic insights into the natural fire frequency of the monument.

To gain a greater understanding of the past fire history, the coniferous forest community and the juniper-shrub community were traversed to locate fire scarred ponderosa pine (*Pinus ponderosa*) snags. On the basis of their location and their degree of preservation, 83 were selected for sampling. Sampling involved the removal of a 4-inch transverse section through the fire scarred portion of the bole. At the present time these sections have been prepared for analysis and are being analyzed through use of dendrochronological techniques. These techniques involve utilization of the patterns of annual ring width variability to date past occurrences. In this case we are concerned with those fires which produced the scars exhibited by the sections which were collected. Preliminary results indicate that this will facilitate reconstruction of the past 250-300 years of fire history.

A portion of the past field season also was devoted to activities directed toward the fire ecology of the monument.

Four 1/5-acre plots were established in a cheatgrass-sagebrush community near the northern monument boundary. These were sampled by means of line transects to determine the floristic composition and percent cover. In addition, each plot was sampled to determine average fuel loading. Following construction of fire lines, two plots were burned on the evening of 29 July. These plots were resampled following the fire to determine reductions in fuel loadings and will be resampled during the next field season to determine any changes in percent cover or species composition as a result of the fire.

To examine possible effects fire might have upon sexual reproduction of grass and herbaceous species which are components of the monument's flora, seed was collected from six grass species and two herbaceous species and is presently being subjected to treatments of moist and dry heat which simulate conditions produced by natural fires. The effects those treatments have upon seed viability and germination percentage will be recorded and analyzed and should be highly useful in determining the fire autecology of these species.

On the basis of the work so far, it is felt that the study should proceed as planned and outlined in the original proposal.

# # #

NATIONAL CAPITAL PARKS

THE FALTERING DUTCH ELM DISEASE CONTROL PROGRAM IN WASHINGTON, D. C.

INVESTIGATOR: Horace V. Wester
National Capital Parks

SUMMARY OF PROGRESS: The National Capital Parks and the District Government have had one of the best municipal Dutch elm disease control programs in the country. This can be largely attributed to the National Capital Parks and the District Government establishing a city-wide control program for this disease in 1951. The need for this city-wide control was apparent due to rapid increase of this disease since it was first found here in 1947. Without this control program, Washington would have lost its valuable heritage of elms.

Since 1951, it has been my responsibility to confirm suspect cases of the disease by culturing prior to recommending removal. This has allowed me to monitor the quality of the control program from year to year. The program has usually been well supported, except in recent years for the removal of diseased elms on Theodore Roosevelt Island and the C&O Canal in the District which has created important sources of infection to valuable elm plantings in West Potomac Park, the Ellipse, White House, Washington Monument grounds, the Mall, and street plantings in northwest Washington.

My 1972 Annual Report correlated excessive high disease incidences in park reservations to uncontrolled build-up of disease sources on Theodore Roosevelt Island and in less degree in elm plantings on the streets of Washington from similar uncontrolled conditions in the C&O Canal. These conditions have been allowed to persist in 1973 and 1974 with somewhat similar disastrous results, particularly in repsect to the valuable elm plantings in West Potomac Park, etc., across the Potomac from Theodore Roosevelt Island. Table 1 gives Dutch elm disease incidence data in the District for 1973 and 1974.

Failure of the National Capital Parks to be responsive to my 1972 Annual Report on this important matter is not in accordance with the following agreements and the Plant Quarantine Act.

1. Cooperative Agreement between the National Capital Parks and the District Government, 9 July 1951.

2. Cooperative Agreement between Trees and Parking Division Highway Department, District of Columbia, Office of National Capital Parks, Department of the Interior and the Bureau of Entomology and Plant Quarantine Agricultural Research Administration, United States Department of Agriculture, October-November 1952.

The latter agreement provides legal support by the Plant Quarantine Act in enforcement of the removal of Dutch elm disease sources of infection in the District of Columbia. The Secretary of Interior had requested the Secretary of Agriculture for this enforcement authority mainly to control the disease on private property in the District of Columbia. Therefore, removal of Dutch elm disease sources of infection in the District is mandatory by law.

Table 1. DUTCH ELM DISEASE INCIDENCE IN AMERICAN ELMS UNDER STREET AND PARK CONDITIONS IN WASHINGTON, D.C. FOR 1973 and 1974

Location	Date Invent.	Total elms	1973		1974	
			No. dis.	%	No. dis.	%
D. C. streets	1968	20,486	254	1.3	238	1.1
White House	1968	27	2	7.4	1	3.7
Ellipse grounds	1972	220	6	2.7	6	2.7
Washington Monument grounds	1972	148	3	2.3	4	2.6
Mall	1971	446	5	1.1	10	2.2
West Potomac Park	1972	659	39	6.0	27	4.0
TOTAL for parks		1,500	55	3.7	48	3.2

# # #

RESTORATION OF DYKE MARSH

INVESTIGATORS:
Richard Hammerschlag)
Jack Longworth)
Mark Smith) National Capital Parks
Tom Patin)
Hanley Smith)

SUMMARY OF PROGRESS: Contracted procurement of bottom contour map of Dyke Marsh; survey and boundary line determination--1974. Production of potential restoration design, diking arrangement, and quantitation of materials by Scott Davis and Jack Longworth, NCP. Enlistment of cooperative support of Dyke Marsh restoration with the Dredge Material Research Program of the Corps of Engineers, Waterways Experiment Station (WES), Vicksburg, Mississippi.

RECOMMENDATIONS: Development scope of work outline for a feasibility study for restoration of Dyke Marsh; effect feasibility study with NCP serving as contract manager with financial support from WES; and completion of environmental assessment.

# # #

THE LANDFILLS: KENILWORTH AND OXON COVE

INVESTIGATORS: James C. Patterson) National Capital Parks
James L. Sherald)

SUMMARY OF PROGRESS: The problems of our landfills were called to our attention by the then Superintendent of NCP-E, Abner Bradley. His questions involved management, namely, what are the plant and building problems, etc. Since then, numerous references and personal contacts have indicated severe problems do exist, management restrictions exist, and that breakdown is at least "950" years. We have gathered considerable data on soils and gas wells on the Kenilworth landfill, and we have designed several experimental setups for turf plots, gas well locations, and soil profile analyses for Oxon Cove. The studies at Oxon Cover, with the exception of the turf plots (they were begun last fall), will be initiated this spring.

The soil profiles observed at Kenilworth indicate that at least a 3-ft mantle of earthy material overlies the refuse. A layer of the Christiana soil series (predominately a heavy clay soil) was compacted and immediately overlies the refuse in a thin horizon which ranges from 7 to 12 inches in thickness. This horizon in effect prohibits or entraps methane gas produced from refuse decay. The soil horizons above the Christiana series are quite heterogeneous and contain artifacts such as bricks, cinder blocks, wood fragments, etc. The dominant characteristic of the soil is one of extreme compaction.

Surface textures are silt loam to loam and have been influenced by a 3-inch application of sewage sludge.

The soil profile characteristics and data are from four soil profiles:

pH and total cation exchange (CEC)

Surface Soil	6.9 - 7.3	10.2 - 20.2 me/100 g
Subsoils	4.8 - 7.8	7.5 - 15.3 me/100 g

The bulk density range is from about 1.50 to 1.9 + g/cc. The moisture holding capacity is low and the permeability is described as very slow.

Range of heavy metals expressed as total - ppm

Heavy Metal	Ap - horizon	Subsoil
Zn	275 - 1025	54 - 795
Pb	154 - 277	54 - 222
Cu	128 - 412	20 - 70
Cd	7 - 15	5 - 28
Ni	28 - 35	20 - 54

These data summarize our initial findings. We do feel, however, that landfills are best used as open grassy areas or for recreational facilities. Trees and shrubs at Kenilworth are having difficulty surviving due to the heavily compacted soils, poor soil-water relationships, and a poor atmosphere. The general feeling concerning the soil atmosphere is that the methane produced by decaying refuse displaces the oxygen resulting in generally high percentages of carbon dioxide and methane. Presumably, the carbon dioxide abundance causes lack of plant vigor and possibly death. Concerning building construction, this seems hazardous at best and the cost of construction is nearly prohibitive.

These studies, particularly those relating to the soil atmosphere and plant survival, will be continued in conjunction with Dr. Sherald.

# # #

SOIL MODIFICATION STUDIES (HAINS POINT AND FT. HUNT)

INVESTIGATOR: James C. Patterson
National Capital Parks

METHODS: Earlier we reported our search for another recreation area where clayey soil predominated but we have been unable to locate a suitable site. This is probably fortunate when one considers the marginal problems associated with this type of a site.

The amendments (light-weight aggregates) being used are sintered fly ash, expanded slate, and coarse construction sand. They were chosen principally because they are economically competitive and should produce the desired results.

The plot layout is a randomized, complete block design with three replications. In addition, one-half of the plots have received an application of digested sewage sludge as an organic additive. Basic data analyses include particle size, bulk density, particle density percentage and pore space distribution, infiltration - percolation characteristics, cation exchange, and general soil fertility analyses. The plots are maintained by NPS maintenance staff through their regular park operations. Once again, long-term benefits should be realized to make this type of soil modification worthwhile.

SUMMARY OF PROGRESS: The Hains Point plots have been under use for nearly 4 years and are yielding very encouraging results. The most important parameter which is measured is the bulk density which has been termed the "index of compaction." (Pearson, R. W. 1966. Soil environment and root development. Pages 95-126 *in*, *Plant Environment and Efficient Water Use*, edited by W. H. Pierre; published by American Society of Agronomy.) The bulk densities are: expanded slate, 1.39 g/cc*; sintered fly ash, 1.43 g/cc*; coarse sand, 1.52 g/cc; and control, 1.52 g/cc. (* sign. different at 5% level).

The other important parameter is the percent pore space which has been calculated as follows:

$$\% \text{ pore space} = 100 \left(1 - \frac{\text{bulk density}}{\text{particle density}} \right)$$

Amendments	% pore space (avg. for 12 plots)
Sintered fly ash	36.5
Expanded slate	35.8
Coarse sand	38.0
Control	33.2

We have not yet tested for significance but there seems to be a significant difference. Similar analyses involving infiltration rates and amounts seem to indicate that the amended plots have a better ability to handle more water per unit time than the unamended plots; the same is true at the Fort Hunt plots (bulk and particle densities are presently being run).

Results to date are very encouraging with respect to improvement of the soil's physical environment. Presumably by improving the soil physics of a heavily compacted area the soil resource is better able to support vegetation, especially trees and larger shrubs. Turf will also be better able to survive under the improved soil physics, particularly in areas not under the most intense uses.

These tests will be rechecked periodically to determine the long-term conditions. Hopefully the soil amendments will perform as well over the years.

# # #

SOIL ATMOSPHERE ANALYSIS OF KENILWORTH LANDFILL PARK

INVESTIGATORS: James L. Sherald) National Capital Parks
James C. Patterson)

SUMMARY OF PROGRESS: In conjunction with the ESL general soils program, a project was initiated to examine the soil atmosphere at the Kenilworth Landfill Park. The project is in response to the fact that sanitary landfills are known to generate methane and carbon dioxide gas via microbial digestion of landfill material. Subterranian gas production could potentially unbalance normal soil atmosphere by displacement of O_2 and N_2. Trees and shrubs grow optimally when oxygen comprises 21% of the soil atmosphere. Soils with atmospheres containing less oxygen could stress normal plant growth resulting in a decline in vigor and possibly death.

Nineteen sampling sites were selected at the landfill. Each location consisted of sampling wells at 2 and 5 ft. Samples were extracted from the wells with a hyperdermic syringe and analysed by gas chromatography. A preliminary sampling throughout July indicated that in some locations O_2 comprised as little as 5.0 and 0.2% of the soil atmosphere at 2 and 5 ft respectively, while in other locations a normal soil atmosphere prevailed.

In order to establish a soil atmosphere profile for the area, sampling will be resumed in the spring of 1975 and continued throughout the growing season.

A similar analysis is currently being planned for the Oxon Cove golf course which will also be established on a sanitary landfill. The Oxon Cove location offers a unique opportunity in that the area contains both incinerated and unincinerated trash in separate and distinct localities. An attempt will be made to determine to what extent incineration reduces the level of methane and carbon dioxide in the soil atmosphere.

A future analysis of urban soil atmospheres is also anticipated. Such a study would determine what effects urban stress factors, such as soil compaction and limited growing area, have on soil atmosphere.

# # #

SOIL SURVEY OF WASHINGTON, D. C.

INVESTIGATORS:
James C. Patterson, National Capital Parks
Robert Shields, Soil Conservation Service
D. S. Fanning, University of Maryland
John Hack, U. S. Geological Survey

SUMMARY OF PROGRESS: The cooperative soil survey of Washington, D. C., is, to the best of our knowledge, the first comprehensive soil survey of an urban environment and will be geared to the many interpretative needs of National Capital Parks.

The ESL is the prime cooperator with the USDA-Soil Conservation Service and we have the responsibility for characterizing and intensively mapping the soils of East and West Potomac parks, the Mall, and Kenilworth and Oxon Cove landfills. We are monitoring water table levels (both perched and/or ground water levels), soil atmosphere levels, soil moisture tension capabilities, soil temperature fluctuation, bulk and particle densities, infiltration rates, and some of the soil chemistry aspects.

Cliff Stein, a graduate student at the University of Maryland and supported by the ESL (Master Memorandum of Understanding), has completed the soil mapping of Potomac parks and portions of the Mall. To date, the SCS has mapped approximately 25,000 plus acres of the approximate total of 37,000 acres in the District of Columbia.

Soil survey mapping or identification is being completed at the soil series level. In regard to heterogeneous soils, an attempt will be made to identify these soils to one or more predominate soil series name(s) and to record these with the dominant soil series listed first. In this way, better interpretative tables can be compiled. In particular, special interpretations will be made with regard to horticultural or ornamental plantings, the standard engineering and recreation interpretations, and there will also be a geologic section. Data will be included on the percentage of impervious areas (roofs, streets, etc.) vs. pervious areas.

The soil maps which will appear are being compiled on aerial photographs at a scale of 8 inches per mile, about twice the detail of conventional surveys. The published maps will be photographically reduced but the final product will still be much more detailed than conventional soil surveys.

Concerning any future course, the ESL will continue to evaluate and support the survey's findings and offer assistance to NPS personnel in an interpretative nature. Some studies, such as the water table studies, will be continued for a couple of years to collect further document fluctuations particularly as it relates to cherry trees.

# # #

IMPACT OF EXOTIC PLANTS ON INDIGENOUS VEGETATION

INVESTIGATOR: L. Kay Thomas, Jr.
National Capital Parks

SUMMARY OF PROGRESS: This past year was spent in unraveling the problem of the impact of exotic plants on the indigenous vegetation. The whole problem was divided into two parts. One part deals with limiting factors and other aspects of dynamic ecology on three important exotic species. The second part is a structural survey of the vegetation in National Capital Parks to ascertain the exotic impact as a function of ecological dominance.

The dynamic aspects of the problem were terminated and a final report was written early this past year. An abstract of that 300-page report (which was also accepted as a Ph.D. dissertation) follows:

Man's impact on the environment in his absence can continue indefinitely by means of exotic plants which he has introduced or allowed to become established. All three of the exotic species studied--*Lonicera japonica* Thunb., *Hedera helix* L., *Iris pseudacorus* L.--became established in areas occupied and disturbed by man long ago.

The consequences of this establishment are that the ornamental vine species *L. japonica* and *H. helix* are destroying the forests (except the swamp) of Theodore Roosevelt Island even though it is now uninhabited by man; succession is directed toward a vine-dominated community. Once started, *L. japonica* tends to create its own habitat. Management for of Dutch elm disease fungus, *Ceratostomella ulmi* (Schwarz) Buisman has greatly increased the presence of these two vines.

The marsh of *Peltandra virginica* (L.) Schott & Endl. is being replaced by the introduced *Iris* with subsequent decrease in wood duck (*Aix sponsa* (Linnaeus)) food supply. The *Iris* vegetation tends to create its own habitat, and near the forest edge, it speeds up succession from marsh to swamp. The result is that there will be little or no marsh on the island. Due to a recent increase in river level during the growing season, the *Iris* is dying out in some places, and the marsh to swamp succession is slowed down from its former rate.

These conclusions are the results of an extensive study using 190 statistically analyzed experiments and surveys correlated with the investigations of others as published in the literature. Most of the experiments and all of the surveys took place on the 35.74 ha Theodore Roosevelt Island which is administered by the National Park Service, U. S. Department of the Interior and is located in the Potomac River at Washington, D. C.

On the upland area of the island, light was found to be a strong limiting factor for growth of *L. japonica*. Growth increases with light intensity. This evergreen vine besides overwhelming and killing small trees and shrubs, prevents reproduction, especially of the tree species *Ulmus americana* L., *Prunus serotina* Ehrh., and *Liriodendron tulipifera* L. which are among the principal dominants of the island upland.

Light is not as strong a limiting factor for *H. helix* as for *Lonicera*, but on the upland there is no other factor that is stronger. On the flood plain, the height of the water table limits the distribution and growth of *Hedera*. *Hedera* suppresses growth of native herbs in both habitats, but the suppression is greater on the upland. This evergreen is a tendril liana that is not limited to climbing small trees. It climbs overstory and understory trees. Since it grows all or most of the winter while its hosts are dormant, it is able to shade them out and kill them. *Ulmus americana* is particularly vulnerable probably because of reduced vigor caused by the Dutch elm disease.

Whenever a tree falls in the forest, both of these exotic vines are encouraged. However, a great boost has been given to *H. helix* by cutting *U. americana* (elm) trees for control of *C. ulmi*, the fungus causing Dutch elm disease.

In the marsh, the length of time that *I. pseudacorus* is inundated by water is closest to a factor limiting its growth. The longer the inundation, the lower is the growth rate of *Iris*. Although this factor is not a limiting factor as such, it was sufficiently strong to predict accurately that the recent *Iris* decline could be correlated with a rise in the river level during the growing season. In the swamp-marsh transition of the marsh, *Acorus calamus L.* is an important species which invades and takes over *I. pseudacorus* areas. Unlike the *Iris* which can spread both by rhizomes and seeds, *Acorus* spreads almost entirely by rhizomes.

Iris grows in areas that would otherwise be occupied by *Peltandra virginica*, an important food of *Aix sponsa* (Linnaeus), the wood duck. Also, *Iris* competes directly with species of *Salix*. *Salix nigra* Marsh. requires mineral soil for a seed bed and *I. pseudacorus* apparently also grows only on mineral soil and grows faster than these trees. The *Iris* appears to create its own habitat from the marsh and by so doing and by outcompeting the *Salix* spp., it short-circuits the marsh to swamp succession and provides a seed bed for swamp trees such as *Fraxinus pennsylvanica* Marsh.

The second part of the study continues and will continue for several years. I recognize that coincident with the structural study comes basic data upon which subsequent synthesis and anlaysis will result in the Resources Basic Inventory (RBI).

The first problem in the survey is to develop a methodology for sampling different habitats and defining their limits with efficiency and accuracy. Small parks are being worked on first to develop the needed techniques and at the same time complete part of the survey. The statistical analysis of the data, however, takes a tremendous amount of time.

In the past year statistical analysis has proceeded on Wolf Trap Farm Park, Theodore Roosevelt Island, and Little Island. Statistics for Little Island are nearing completion.

About 61 man days were spent in the field gathering data from this island and about 150 man days have been spent, thus far, in its statistical analysis.

Field work was done and completed for Wolf Trap Farm Park this past summer. Part of the field work was done for the Anacostia River areas.

Next year, I hope to have ready access to sufficient statistical machines including a computer to do the necessary analyses in a more reasonable time. This will enable me to do the biological analyses which must predate the information for the Resources Basic Inventory. Hopefully I will have the RBI completed on one or two areas by the end of next year.

# # #

REMOTE SENSING FOR EARLY DETECTION OF DUTCH ELM DISEASE

INVESTIGATORS: Richard Hammerschlag) National Capital Parks
Gary P. Clemons)
Walter Sopstype, NASA

SUMMARY OF PROGRESS: Several aerial photographic techniques were investigated for efficacy in providing early detection of the Dutch elm disease. The systems which showed the greatest promise were multispectral photography in combination with an additive color viewer and biband ratioing coupled with scanning microdensitometry. The multispectral photographic system, particularly with further refinement, might provide the practical tool that is needed. It will provide superimposable frames to insure complete registration throughout the combination image. It is predicted that a more judicious choice of narrow band filters will yield imagery with greater contrast between healthy and declining elm trees. Bands of particular value should focus at 570 nm, 640 nm, and 720 nm. There should be further use of the scanning microdensitometer as an analytical tool to compare reflectance values from healthy and variously stressed vegetation. In practical terms though the biband ratioing technique requires too large a support system for it to be of general value at this time. There may be valid uses for color infrared film detection of long-term plant stress. The low sensitivity of the film response to early changes in plant reflection, however, combined with the general lack of specificity and reliability of the response when it occurs, makes color infrared a poor choice for early detection of Dutch elm disease.

Since there is a loss of definition of the darker objects through the copying process, any detailed spectral analysis of imagery ought to be made on the original film.

RECOMMENDATIONS: The conceivable benefit for a sensitive detection system for plant stress is great enough to warrant continued work toward satisfactory accomplishment of the goal. During the summer of 1975 we intend to refine the photographic system and place more emphasis on ground truthing to evaluate predictions made from the 1974 imagery.

# # #

SHADE TREES IMPROVEMENT PROGRAM

INVESTIGATOR: Horace V. Wester
National Capital Parks

SUMMARY OF PROGRESS: In spring 1974, I furnished the Princeton Nurseries propagating materials of 10 of my shade tree selections, selected with the object of improving the ornamental quality of shade trees and lowering their maintenance costs in the urban environment. At the end of this season, this nursery had the following quantities of 1-year-old trees from these selections growing in their nursery which will be available to the National Capital Parks in the fall of 1975.

24	*Ulmus japonica* x *Wilsoniana*
5	*Ulmus glabra* - Ft. McNair
18	*Ulmus americana* 3-178
11	*Ulmus laevis* - Fairchild
26	*Ulmus hollandica* - 1409
13	*Ulmus parvifolia* - Fessenden St. & Balt. Rd., Washington, D. C.
18	*Zelkova carpinifolia* - Union Square
19	*Zelkova Schneideriana* - Glendale
14	*Zelkova sinica* - National Arboretum
75	*Aesculus carnea* - Ft. McNair - for replacement of Buckeye trees, Buckeye Drive, East Potomac Park

Shade Tree Selections for the Urban Ecology is in preparation.

# # #

ENVIRONMENTAL DISASTER IN THE POTOMAC AND ANACOSTIA ESTUARIES IN THE WASHINGTON, D. C. AREA

INVESTIGATOR: Horace V. Wester
National Capital Parks and Smithsonian Institution

SUMMARY OF PROGRESS: Pollution problem. Surveys in 1973 and 1974 showed that major losses of aquatic flora have occurred in recent years in the Potomac and Anacostia estuaries of the Washington, D. C. area. In the Potomac, the affected area extends from Theodore Roosevelt Island, Washington, D. C., 12 miles downstream to Mount Vernon, Virginia. In the Anacostia, it extends from Bladensburg, Maryland, 6.5 miles downstream to its junction with the Potomac. Localization of the problem within the Washington, D. C., area, identified the source within this area.

Effects on aquatic plants and wildlife. Problem has resulted in great decrease in species diversity in a broad community of aquatic plants and wildlife depending on this vegetation for life support. This makes the problem an environmental disaster. Some of the more important drastically affected aquatic plant species include wild rice, pondweeds, water weed, and wild celery. Tables I and II show how the problem has affected some of the local marsh flora and wildlife.

Conditions associated with the problem. Pollution by-products from the densely populated Washington area, including oil, have been associated with the problem. This, however, does not seem to include nutrient pollution from the local sewage treatment plants resulting in eutrophication or oxygen depletion as a result of excess algae growth. The latter conclusion is drawn from the fact that the affected aquatic plants are well adapted for these conditions and moreover wild rice, one of the primary aquatic plants affected in the Washington area, has not appeared affected at the outfall of the effluent from the Piscataway sewage treatment plant, only 6.5 miles south of Washington and within the pollution zone. The wild rice stand in Piscataway Bay, however, is in the inner bay. Water flowing into the inner bay from Piscataway Creek and effluent from the sewage treatment apparently are factors in keeping pollution from the Potomac sufficiently diluted to provide protection to the wild rice which still flourishes in the inner bay, but not in the outer bay, fronting on the Potomac.

Research in 1975. Further research on aquatic plant species affected by problem and pollutants likely involved with problem will be conducted in 1975.

Table 1. EFFECTS OF ENVIRONMENTAL PROBLEM ON FORMERLY PREDOMINANT OR COMMON AQUATIC VEGETATION IN THE POTOMAC AND ANACOSTIA RIVERS IN THE WASHINGTON, D. C., AREA

Scientific name	Common name	Observations in 1973 and 1974
Typhaceae		
Typha angustifolia	Cattail	Dying out on shores of Theodore Roosevelt Island and Goose Island
Potamogetonaceae		
Potamogeton crispus	Curly pond weed	Eliminated
Potamogeton pectinata	Sago pond weed	Eliminated
Vallisneriaceae		
Elodea canadensis	Water weed	Eliminated
Vallisneria spiralis	Wild celery	Eliminated
Poaceae		
Zizania aquatica	Wild rice	Almost eliminated
Araceae		
Orontium aquaticum	Golden club	Eliminated
Peltandra virginica	Arrow arum	Dying out on shores of Theodore Roosevelt Island and Goose Island
Pontederiaceae		
Heteranthera reniformis	Mud plantain	Eliminated
Nymphaeaceae		
Castalia odorata	White water lily	Almost eliminated
Nelumbo lutea	American lotus	Eliminated, apparently prior to 1919
Cabombaceae		
Cabomba caroliniana	Cabomba	Eliminated
Onagraceae		
Epilobium coloratum	Willow-herb	Dying out on shores of Theodore Roosevelt Island

Table 2. EFFECTS ON SOME NOTABLE WILDLIFE ATTRIBUTED TO MASSIVE DESTRUCTION OF NATURAL FOOD SOURCES IN THE POTOMAC AND ANACOSTIA RIVERS IN THE WASHINGTON, D. C., AREA

Scientific name	Common name	Observations in 1973 and 1974
Anatidae		
Aythya valisneria	Canvasback	Formerly common winter visitor, now rare
Anas acuta	American pintail	Formerly common winter visitor, now rare
Accipitriidae		
Circus cyaneus	Marsh hawk	Formerly common resident, now uncommon
Haliaetus leucocephalus	Bald eagle	Formerly common resident, now rare visitor
Ardeidae		
Casmerodius albus	American egret	Formerly common visitor, now rare
Leucophoyx thula	Snowy egret	Formerly fairly common visitor, now rare
Florida coerulea	Little blue heron	Formerly fairly common visitor, now rare
Rallidae		
Porzana carolina	Sora rail	Formerly very common visitor, now rare
Scolopacidae		
Philobela minor	Woodcock	Formerly very common resident, now somewhat rare
Icteridae		
Dolichomyx oryzivorus	Bobolink	Formerly very common visitor, now rare

# # #

ROCKY MOUNTAIN NATIONAL PARK

RESPONSES OF ELK TO HUMAN DISTURBANCE IN ROCKY MOUNTAIN NATIONAL PARK

INVESTIGATOR:	James A. Bailey Colorado State University
OBJECTIVES:	To quantify effects of human disturbance on bugling rates, observability, movements, and social activity of elk during rutting and on the winter range.

SUMMARY OF PROGRESS: This preliminary report summarizes data on rutting elk collected in and near Horseshoe Park during 21 September to 29 October 1974. Most but not all of this data has been analyzed and interpreted. Information on effects of human disturbance on wintering elk is still being collected.

Elk in Rocky Mountain National Park use open meadows during morning, evening, and nighttime hours. This minimizes encounters with people. The degree to which this behavior may be an adaptation to numerous people in the park or to the elk reduction program which ended in 1962 is not known. In this sense, we did not observe a completely undisturbed elk herd even on mornings without traffic in Horseshoe Park.

We cannot prove that abundant traffic in Horseshoe Park had no effect upon the behavior of rutting elk. Statistical treatment of the data only demonstrated that a "large" effect was unlikely. Our results suggested small effects of traffic volume upon bugling rates and numbers of elk observed in evenings and upon the time of morning departure of elk from the open meadow. However, these results may have been due to sampling error. Further, significant correlations between data collected at Endovalley and at Horseshoe Park and between data from mornings and evenings of the same day indicate that these data are not independent. Thus the consistent trends for weekday evening bugling rates and numbers of elk observed to be greater than weekend evening bugling rates and numbers of elk observed are, in part, three measures of the same phenomenon and cannot be considered as three independent observations, all suggesting an effect of traffic volume upon elk. If the implications of a small effect of traffic volume upon behavior of rutting elk are considered important, this study should be repeated to increase the sample size and test for the existence of that effect. Use of ratio telemetry would improve the likelihood of detecting effects of traffic volume on rutting elk.

Photographers, other people, and vehicles that attempted to move close to elk, and people using spotlights usually reduced elk-watching and bugle-hearing for others by initiating premature movements of elk from open areas into the surrounding forest.

Harems harrassed by approaching people moved quickly and seemed disorganized. This increased energy expense. Harem bulls, in particular, may expend more energy defending disorganized harems. The implications of this activity, at present levels of human disturbance or at increasing levels that may occur in the future, are unknown.

Since most elk arriving in Horseshoe Park after 14 October were observed in mornings but not in evenings when traffic was greater, it is suggested that these late-arriving animals respond differently to disturbance, compared to elk observed before 14 October. The late-arriving elk may summer high in Rocky Mountain National Park, where people are less abundant, and be less adapted to human disturbance. This intriguing possibility may deserve further study.

# # #

SOUTH FLORIDA

ARSENIC ACCUMULATION IN STONE CRABS AND SPINY LOBSTERS

INVESTIGATORS: Clyde J. Hurst) National Park Service Science Center
Brenda J. Little)

INTRODUCTION: During the course of the South Florida Ecological Study, stone crabs, *Menippe mercenaria*, and spiny lobsters, *Panulirus agrus*, were sent to the WARF Institute for analysis of certain pesticides and heavy metals. The results from this sample indicated that arsenic was found in concentrations (8.97 ppm-18.8 ppm wet wt.) above expected natural levels.

OBJECTIVES: The purpose of this study was to attempt to reproduce the findings of the WARF Lab and to further differentiate the tissue types in which the suspected accumulation took place--body muscle, claw muscle, exoskeleton, viscera, gills, or ova. The scope of the study included the sampling of areas in the South Florida Ecological Study at various times of the year in order to determine if there were seasonal variations in the arsenic concentrations and to ascertain whether or not there was chronological accumulation of the arsenic in marine crustaceans.

METHODS: A sample of *Menippe mercenaria* was collected, frozen, and shipped to the National Park Service Science Center where it was thawed, dissected into the before-mentioned tissue types, dried in an oven at 80°C, and finally homogenized. The individual homogenized tissues were stored in a freezer until analyzed. Tissues to be analyzed for arsenic were dried at 80°C overnight, weighed, and transferred to vicor crucibles for dry ashing. One to two gram samples were pre-ashed using 50% magnisium nitrate (3 ml/gram tissue) in a gravity convection oven starting at room temperature and increasing slowly to 325°C for 4 hours or until the sample was completely charred. Samples were then transferred to a muffle furnace and ashed at 500°C overnight. The residue was dissolved in 6NHCl and the arsenic was reduced by means of zinc and HCl to arsine, which was complexed with silver diethyldithiocarbamate and determined colorimetrically at 540 nm. (1)

RESULTS AND DISCUSSION: The results thus far obtained substantiate the elevated arsenic concentrations previously reported by the WARF Laboratory. Present data indicate that the greatest accumulation of arsenic is in the viscera of the stone crab at a concentration of 53.5 ppm. The claw muscle contained 33.8 ppm arsenic and the exoskeleton 10.9 ppm. The remaining tissue types are currently being analyzed.

CONCLUSIONS: The data that have been generated thus far are indicative of an accumulation of arsenic in the marine crab *Menippe mercenaria* taken from the designated study area. During the next year we plan to collect additional samples of stone crabs and spiny lobsters in order to determine whether seasonal variations exist and to further determine to what extent the accumulation is a chronological phenomenon. In addition, project design includes the elucidation of the physiological role of arsenic in marine crustaceans including the organic state of the accumulated arsenic. The presence of arsenic at relatively high levels in marine fauna has been documented (2,3); however, little is presently known as to its form or function (4).

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YOSEMITE NATIONAL PARK

PRELIMINARY FIELD SURVEY OF POTENTIAL FOREST BIOMASS AND WOOD LITTER PRODUCTIVITY RESEARCH SITES IN YOSEMITE NATIONAL PARK

INVESTIGATOR: William B. Davilla
San Jose State University

SUMMARY OF PROGRESS: Numerous sites in the Tuolumne Meadows region were explored and evaluated by methods developed by this researcher during the Sierra Club impacts study, for the suitability of analysis of firewood production and forest biomass. Sites considered suitable to date are: (1) Rafferty Creek drainage of Lyell Fork; (2) Delaney Creek, 1 mile north of Dog Lake; (3) Dana Fork, just above Dana meadows; (4) Cold Canyon area; and (5) May Lake area (possible exception due to high use). Sites were chosen that resembled areas now in heavy use by national park users and that were representative of the tree structure and composition of areas in heavy use in the park. Recommendations are that these sites and maybe others be set aside for baseline evaluation of woodlitter production, forest tree biomass, and productivity. Each site will be monitored for at least 2 years for rates of production which can be used as a comparison for other areas in the rest of the park. Further, to substantiate these comparisons on a park-wide basis, use can and should be made of aerial photographs that have already been made of the park to categorize each section of wilderness as to its potenital carrying capacity for firewood consumption and production. Finally, monitoring of the number of people at the roadheads who have fires and the reasons for these fires will help to derive a relationship between the estimate of the amount of firewood consumed to the amount produced each year.

# # #

HIGH ELEVATION TRAIL REVEGETATION STUDIES

YOSE-N-2217

INVESTIGATOR: Rexford E. Palmer
University of California, Davis

SUMMARY OF PROGRESS: During the summer of 1973, a series of experiments was begun in Tuolumne Meadows, Yosemite National Park, to determine the feasibility of developing methods for the removal of old trail scars in high elevation areas. The experiments were performed on a section of the closed portion of the Lyall Fork trail near the Tuolumne Meadows Lodge.

Numerous techniques were tried in an attempt to discover the kind of manipulations needed to produce revegetation of trail scars. Now, 1.5 years later, we may have a method. Briefly, the method consists of breaking up the soil compaction by digging, and then replanting the site with chunks of sod from the trail edge. In plots where this technique has been used, the sod chunks have begun to grow and have produced a section of former trail that looks strikingly similar to the surrounding meadow.

As yet, no problems with frost heaving have been encountered. Lack of frost heaving effects may be due to the relatively great depths to which digging was extended. Also, frost heaving is probably not a common occurrence in the type of vegetation being studied, i.e., a relatively dry *Carex exserta* shorthair meadow.

# # #

THE IMPACT OF VISITOR USE ON PLANT, BIRD, AND SMALL MAMMAL COMMUNITIES OF YOSEMITE NATIONAL PARK

INVESTIGATORS: T. C. Foin, Jr.) University of California, Davis
E. O. Garton)

SUMMARY OF PROGRESS: Birds. A pair of transects was laid out in campground and comparable non-campground areas and bird species usage was assessed at each station along the transects. Quantitative analysis of vegetation and other habitat variables were conducted at each station. The data were analysed by: (1) comparing bird species composition and diversity in each transect; (2) determining the habitat preferences of each species; and (3) assaying the importance of human use of areas relative to habitat variables in determining the usage of areas by each bird species. The results demonstrate that there are significant direct (through actual presence of visitors, vehicles, and equipment) and indirect (through changes in vegetation, topography, and habitat structure of the area) effects of campgrounds on the bird community in this area.

Small mammals. For the second year a grid was live-trapped for small mammals. The grid covered an area containing campground and non-campground zones. A new grid was also laid out in the pet section of the campground. A census of the small mammals was performed at three times, before, during, and after the main campground usage. Vegetation and habitat characteristics of the areas were quantified. It was thus possible to measure the changes in the populations of small mammals throughout the summer season and relate these changes to visitor use and habitat characteristics of the areas. A report is being prepared for the National Park Service to detail the results of these and the 1973 studies and to suggest their management implications.

Feeding ecology of the White-Crowned Sparrow. This project, conducted at Dana Meadows, is part of a study of dietary selection in vertebrates. The territories of breeding White-Crowned Sparrows in one section of Dana Meadows were mapped. Automatic cameras were used to record the foods brought to the nestlings. Insect abundances were sampled in each territory studied. Extensive observations and some films were taken of feeding behavior. The material is being analyzed and will contribute to the understanding of how animals select their diet from the spectrum of food available to them.

# # #

YOSEMITE, SEQUOIA, AND KINGS CANYON NATIONAL PARKS

SIERRA NEVADA GEOPHYSICAL STUDIES

INVESTIGATOR: H. W. Oliver
U. S. Geological Survey

SUMMARY OF PROGRESS: Measurements of both the earth's gravity and magnetic fields have been made inside Yosemite and Kings Canyon national parks as part of a long-range study of the whole Sierra Nevada. Our objectives are to gain a better understanding of how the mountains were formed, the nature of their isostatic balance, and the origin and depth configurations of the many plutons that together constitute the Sierra Nevada batholith. We are currently measuring the specific gravity and magnetic properties of rocks collected in September 1974 in the Tuolumne Meadows-Mount Gibbs area of Yosemite National Park to help with the interpretation of a new aeromagnetic map of the east-central Sierra Nevada (Aerial Surveys 1974). We are also interpreting the geophysical bore-hole measurements made last summer in a 900-ft well in Yosemite Valley. The density-log data indicate several rhythmic cycles of Quaternary deposition which undoubtedly correlate with glaciation.

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# # #

SOIL TEMPERATURE AT SELECTED DEPTHS BENEATH A BURNING CAMPFIRE

INVESTIGATORS: Dennis B. Fenn) National Park Service Science Center
Raymond E. Burge)

OBJECTIVES: The objective of this study was to determine what effects a campfire has on the physical and chemical properties of soil.

METHODS: Soil texture, soil moisture, and fuel type were tested for their effect on the heat profile generated in the soil column below a burning campfire. One hundred and forty pounds of fuel were consumed in each burn, utilizing mesquite, elm, cottonwood, pecan, red oak, ponderosa pine, and slash pine for test fuels. Charcoal and Presto-o-logs were the only two processed fuels tested, utilizing 5 and 15 pounds each, respectively.

The temperature data were recorded using Iron-Constantine thermocouples, 1/16 inch in diameter and 18 inches long, placed in the soil beneath the center of the campfire at 0, 1, 2, 3, and 5 inches below the soil surface. A specially constructed, 10-channel, continuously recording, portable pyronometer was interfaced with the thermocouples to record the data. Two fires could be monitored simultaneously using five probes per fire. All fires were allowed to burn and cool to ambient conditions undisturbed and unextinguished. Less than one hour was required to feed the entire 140 pounds of fuel into the fire in every test.

CONCLUSIONS: Five major conclusions can be drawn from this study. These are: (1) Organic matter quantity and quality in the upper 3-4 inches in a soil beneath a campfire are altered by the heat generated by the fire. (2) Water-repellent zones within the soil can be induced by the heat of the campfire. This effect is particularly pronounced when the soil is initially moist. (3) Sandy soils get significantly hotter and retain heat longer than heavier textured soils. (4) The presence of free soil water keeps the soil temperature below 100° and reduces the temperature and intensity of the fire itself due to the 560 Kcal/mole heat of vaporization of liquid water. (5) Coniferous fuels burn faster and produce less temperature rise in the soil than deciduous fuels. Elm and mesquite fuels were the hottest burning and longest lasting natural fuels tested in this study. Charcoal produced the highest surface temperatures but was of the shortest duration of effect upon the soil temperature regime due to its rapid consumption.

PLANS FOR 1975: The results of this study will be prepared in manuscript form for submittal for publication in a major soils journal. A report of the management significant results will be prepared for internal NPS distribution.

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